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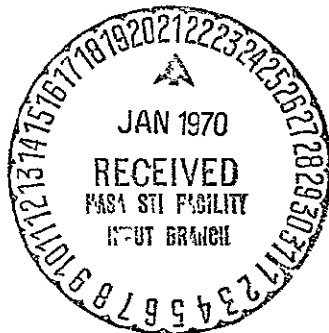
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Goddard Space Flight Center

TECHNICAL/SCIENTIFIC MEETING

on

SPACE BATTERY SPECIFICATIONS



Building Number 3  
Goddard Space Flight Center  
Greenbelt, Maryland

Wednesday, 29 October 1969

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	<u>NAME</u>	<u>AFFILIATION</u>	<u>ADDRESS</u>	<u>TELEPHONE</u>
1				
2	R. L. Beauchamp	Bell Tel Labs Inc, Murray Hill, N.Y.		201-582-3413
3	L. Belove	Sonotone, Cold Spring		914- 9282
4				
5	Jim Bene	NASA-LRC, Hampton, Virginia		703-827-3541
6	E. T. Berry	Aerospace Corp., P.O. Box 95085, Los Angeles, California 90045		213-648-5558
7				
8	W. E. Bishop	TRW Systems, Redondo Beach, California		213-679-8711
9	W. J. Billerbeck	COMSAT, Washington, D.C.		428-4544
10	I. C. Blake	McDonnell-Douglas Astropower Lab., S&E-Qual-AE, Huntsville, Alabama		714-833-1311
11				
12	Sam Bogner	JPL, Pasadena, California		213-354-6795
13	A. M. Bredbenner	Ceramaseal Inc., New Lebanon Center, N.Y. 12126		518-794-6101
14				
15	D. C. Briggs	Philco-Ford, Philco-Ford, Palo Alto, California		415-326-4350
16	A. M. Chreitzberg	ESB, Inc., 2510 Louisburg Road, Raleigh, North Carolina 27604		919-834-8465
17				
18	Earl S. Carr	Eagle-Picner, Jopkin, Missouri		417-623-8000
19				
20	William Campbell	NASA, Goddard		X4739
21	M. L. Cassota	Bell Tel Labs, Inc., Murray Hill, New York		201-582-3199
22				
23	A. J. Cipriani	ESB Ray-O-Vac, 212 East Washington, Madison, Wisconsin 53703		608-255-7201
24				
25	Ed Colston	MASA/GSFC		

	<u>NAME</u>	<u>AFFILIATION</u>	<u>ADDRESS</u>	<u>TELEPHONE</u>
1				
2	E. W. Cohn	NASA/HQ	Code RNW	
3	R. E. Corbett	Lockheed D/62-25, B/151, Sunnyvale,		
4		California 49088		408-642-8832
5	Paul W. Cover	Battelle, Columbus, Ohio	43201	
6	J. D. Dunlop	COMSAT, Clarksburg, Maryland		299-3151
7				301-428-4565
8	A. Fleischer	Consultant, Orange, New Jersey		201-678-1955
9	Stephne J. Gaston	Grumman, OAO Project Plant 41, Bethpage,		
10		New York		516-575-2262
11	P. Goldsmith	JPL, 4800 Oak Grove Drive, Pasadena		
12				213-354-4183
13	Bill Gray	Eagle Picher, 38 Alexander Avenue,		
14		Farmingdale		516-293-6111
15	R. G. Green	Martin-Mariette, Box 158, Denver, Colorado		
16		80001		303-794-5211
17	Sidney Gross	Boeing Company, Seattle, Washington	98124	
18				206-773-2208
19	Gerald Halpert	NASA/GSFC, Code 735, Greenbelt, Maryland		
20		20771		301-882-4739
21	S. Herzlich	Sonotone Marathon Batteries, Monsey, New York		
22				914-605-9282
23	James R. Huff	USAMERDC, Fort Belvoir, Virginia	22060	
24				664-1132-(703)
25	J. H. Jacobs	Union Carbide, Box 6056, Cleveland, Ohio		
	L. E. King	Canadian Government, Defence REsearch		
		Establishment Ottawa, Shirley Bay, Ottawa 4,		
		Ontario		



	<u>NAME</u>	<u>AFFILIATION</u>	<u>ADDRESS</u>	<u>TELEPHONE</u>
1				
2	L. Kirkendall	COMSAT, Clarksburg, Maryland		301-428-4509
3				
4	William E. Kuhn	Spindletop Research Inc., Lexington, Kentucky		606-252-5535
5	J. Kelley	ESB Incorporated, 19 W College Avenue, Yardley, Pennsylvania 19067		215-493-3601
6				
7	E. E. Landsman	MIT Lincoln, Lexington Massachusetts		617-862-5500
8				X5862
9	G. Lyons	Howard Textile Mills, 65 West 36 Street, New York City		212-065-8230
10				
11	John L. Lander	NAF Aero Propulsion Lab., APIP-2, Wright Patterson AFB, Ohio 45433		
12				
13	C. Mashburn	LTU Aerospace, Box 6267, Dallas, Texas 75222		214-HN2-3222 Ex 384
14				
15	D. E. Mains	NAD Crane, Crane, Indiana 47522		812-854-1236
16	G. M. Mackie	Canadian Government, Communications Research Centre, Shirley Bay, Ottawa, Ontario, Canada		13-992-4431
17				
18	Ray Machacek	Department of HEW, Ann Arbor, Michigan		313-662-3241
19				
20	W. C. Mearns	International Nickel Company, 1000 16th Street, Washington, D. C.		
21	Mike Melvin	GE, Washington, D. C.		202-393-3600
22				
23	Walt McCarter	Eagle Picher, Ind., Inc, PO Box 5234, Colorado Springs, Colorado 80911		303-392-6781
24				
25	John McCallum	Battelle		

	<u>NAME</u>	<u>AFFILIATION</u>	<u>ADDRESS</u>	<u>TELEPHONE</u>
1				
2	W. J. Nagle	NASA Lewis, M5-309-1	21000 Brookpark,	
3		Cleveland, Ohio	44135	216-433-4000
4				764
5	Oscar Nietzel	Texas Instruments, Attleboro,	Massachusetts	617-222-2800
6	J. B. O'Sullivan	USAMERDC, Fort Belvoir,	Virginia	22060
7				703-664-5309
8	Palandati	Goddard		
9	J. M. Parry	Tyco Labs, Waltham,	Massachusetts	02154
				617-899-2400
10	Karl E. Preusse	Gulton Ind, Metuchen,	New Jersey	
11				201-548-2800
12	George Price	RAI Research, 36-40	37th Street	LIC New York
				212-EM1-2170
13	M. D. Read	General Electric Company, M.S.D.,	P.O. Box	
14		8555, Rm M2614,	Philadelphia,	Pennsylvania
		19101		
15				215-962-7240
16	Eugene L. Ralph	Heliotek Div of Textron,	12500 Gladstone	
		Avenue, Sylmar,	California	
17				213-EM5-4611
18	Guy Rampel	GE, Gainesville,	Florida	32601
				904-462-3521
19	Allan H. Reed	Battelle, Columbus,	Ohio	43201
20				299-3151
21	J. R. Richardson	NASA-MSFC, S&E-QUAL-AE,	Huntsville,	Alabama
22	Ed Rubin	Texas Instruments, Attleboro,	Massachusetts	
		02203		
23				617-222-2800
24	William E. Ryder	Gulton Ind, Metuchen,	New Jersey	
				201-548-2800
25	H. N. Selger	Gulton Ind, Metuchen,	New Jersey	

	<u>NAME</u>	<u>AFFILIATION</u>	<u>ADDRESS</u>	<u>TELEPHONE</u>
1				
2	Irwin M. Schulman	Gultow Ind, Metuchen, New Jersey		
3	J. M. Sherfey	Goddard		
4	James T. Stemmler	NASA/GSFC, Greenbelt, Maryland	20771	982-5752
5				
6	M. A. Stott	Canadian Government, Communications REsearch Centre, Shirley Bay, Ottawa, Ontario, Canada		13-992-4431
7				
8	Gene Stroup	NASA/GSFC, Arlington, Virginia		
9	Martin Sulkes	USAEcom, AMSEL-KL-PC, Fort Monmouth, New Jersey		201-535-1886
10				
11	Maxine Savitz	Federal City Coll., Washington, D. C.	20001	202-931-3424
12	H. Thierfelder	G.E.SSO, Box 8555, Rm. M2614, Philadelphia, Pennsylvania 19101		215-962-5430
13				
14	John F. Unger	NASA GSFC, Code 71612		GSFC X5752
15	Aiji Uchiyama	JPL, Pasadena, California		213-354-4034
16				
17	Peter R. Voyentzie	GE, Gainesville, Florida		904-462-5561
18	D. C. Verrier	SAFT Corp. of America, 50 Rockefeller Plaza, New York, New York 10021		212-PL7-9130
19				
20	J. W. Yerkes	Textron, Sylmar, California		213-365-4611
21				
22	J. Hennigan	NASA/GSFC, Greenbelt, Maryland	20771	301-982-5547
23	James E. Cooper	NAF Aero Propulsion Lab., APIP-2, Wright Patterson AFB, Ohio 45433		
24				
25	D. W. Maurer	Bell Tel Labs Inc., Murray Hill, New York		201-582-3237

	<u>NAME</u>	<u>AFFILIATION</u>	<u>ADDRESS</u>	<u>TELEPHONE</u>
1				
2	Willard Scott	TRW Systems, Redondo Beach, California	90278	
3				213-679-8711
4	R. A. Steinhauer	Hughes A/C, El Segundo, California		
5				213-648-2997
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
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18				
19				
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P R O C E E D I N G S

HALPERT: I would like to start off this morning by saying hello to you all, and introducing a man who needs no introduction, Tom Hennigan.

HENNIGAN: Well, I would like to welcome you to Goddard Space Flight Center again, and I hope that your visit will be both worthwhile and enjoyable.

This meeting will primarily be concerned with the discussion of the various sections of the interim model specifications for high reliability nickel-cadmium spacecraft cells.

The latest revision is dated April 30, 1969.

Also, on the last day of the meeting, there will be discussions of sealed silver cell specifications.

I would like to cover briefly the course of events that led to the writing of this nickel-cadmium specification. In the latter part of 1967 and 1968, Goddard personnel started to have considerable difficulties with sealed nicad cells. Abnormally high over-charge voltages and hydrogen evolution were indicative of the problems. Battery failures in the Crane test program and failure of the OAO battery during spacecraft integration resulted.

In our efforts to notify users that a serious problem probably existed, it was found that others were having similar or additional problems. A few small meetings

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1 were held with these people that were concerned.

2 At one of the meetings it was proposed that a  
3 symposium be held at Goddard with the main users of nicad  
4 batteries. Also it was requested that Gulton Industries  
5 attend this meeting. At that time the main concern was with  
6 the Gulton cells.

7 The meeting was held in October last year and  
8 involved about 30 organizations, both Government and industry.  
9 The problem areas were reviewed and such topics as plate  
10 quality, cell formation, negative to positive ratio, random-  
11 ization of electrodes, non-woven separators, traceability of  
12 materials, and standard electrical tests were discussed.

13 During the meeting it developed that some type of  
14 materials control, process control, and uniform test proced-  
15 ures were required to avoid future problems, and to assure  
16 long life, high reliability, nicad cells.

17 This would apply also to other manufacturers.

18 As a result of the discussions and apparent require-  
19 ments, several attendees were requested to serve on a working  
20 group to formulate a specification to spell out the desired  
21 design requirements, material and process controls, and test  
22 procedures during the fabrication process.

23 It was not the intent of the working group to  
24 specify how the cells were to be built. Also it was not  
25 possible in a reasonable time period to formulate a

1 specification to encompass all nicad battery processes.

2 The writing of the specification was quite a  
3 difficult task. The working group members had not had a lot  
4 of actual battery experience in the actual making of cells.  
5 Their main experience was primarily as users.

6 Based on the various problem areas as each member  
7 saw them, a specification evolved, termed as a model specifi-  
8 cation, and a few areas may be somewhat idealistic. Basically  
9 it shows good judgment in material and process control. Some  
10 areas are considered critical, some may be considered as  
11 essential, and some as non-critical but good practice.

12 From the results of our discussions here in the  
13 next few days, it is hoped that in the next few months the  
14 specification can be improved and revised so that it will be  
15 generally acceptable to manufacturers and users.

16 Also it was not the intent of NASA and industry  
17 personnel to attach this interim spec to purchase requests,  
18 and require the battery industry to conform overnight. This  
19 would have been impossible. The spec was given wide distri-  
20 bution so that users could have a document from which they  
21 could excerpt information to be incorporated into their own  
22 specifications where they saw a need.

23 It has been noted that in several instances this  
24 has been the case.

25 It is my feeling that a uniform specification would

1 be very useful in approaching standardization, and obtaining  
2 a basis for bidding on purchase requirements.

3 I would like to add that the work is proceeding to  
4 back up the control and test areas of the specification.  
5 Work on materials control is underway at Tyco. Separator  
6 screening and testing is being carried out by ESD Research.  
7 Recently this effort has been directed primarily towards  
8 non-woven materials.

9 Also a request for proposals is out to investigate  
10 process controls. Several in-house efforts are continuing.

11 Now the concept of this material and process control  
12 is not really new to the battery business. Over the last few  
13 years we have been using this type of specification to build  
14 silver-cadmium batteries. Previous to this type of spec or  
15 requirement it was very difficult to get flightworthy silcad  
16 cells. We would have trouble selecting cells, or entire lots  
17 would fail.

18 I would like to at this time introduce the members  
19 that are here, of the Committee.

20 Our Chairman and Coordinator was Mr. Billerbeck of  
21 COMSAT. We have Jerry Halpert, of Goddard, -- I just  
22 upgraded you -- Bob Steinhauer, of Hughes Aircraft, Will  
23 Scott, of TRW, Mr. Dunlop, of COMSAT, and Floyd Ford, of  
24 Goddard Space Flight Center.

25 I would like you to really appreciate what these



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1 fellows did on this spec, and in particular, the patience and  
2 coordination that Mr. Billerbeck showed during the specifica-  
3 tion writing.

4 Mr. Billerbeck would like to say a few words. Thank  
5 you for your attention.

6 BILLERBECK: I have just a very few words. I  
7 certainly would like to start off by thanking the members of  
8 the Committee who participated in helping to put this thing  
9 together so far, because quite a few of them did spend a lot  
10 of their own time, and quite a lot of travel time, in working  
11 on it.

12 Well, I would like to say we've heard considerable  
13 comment on the document so far, and some of it has been  
14 favorable. And so I guess today and tomorrow we give the  
15 battery companies their chance to see what inputs they'd like  
16 to put in at this time.

17 I think, as Tom said, the principal intent of this  
18 meeting is to move on from the original spec. I think we had  
19 sort of a consensus of aerospace users' inputs on the spec  
20 as it now stands. And I think the ground rules were that  
21 this is how they'd like to see a nicad cell built if they  
22 weren't particularly constrained by schedules or dollars.

23 So I think that these meetings now are directed  
24 toward making the spec more relevant. I think that's a  
25 popular word today. And so I think in some cases where we pin

. 1 down specific materials, maybe it's pertinent to think about  
2 making those sections more general, or deleting them. But  
3 on the other hand, I think that the users in general, from  
4 my conversations with them, would like to retain many of the  
5 materials control and process control and end product tests,  
6 as they're called out here. But there certainly is some  
7 refinement in many of these areas that is needed, I'm sure.

8 I think that's important to all of us, because I  
9 feel that the spec as it is, as Tom mentioned, is being  
10 reflected in many procurements now to some extent. And the  
11 eventual spec will certainly be used more, by NASA and by  
12 COMSAT, and certainly I'm sure by other users.

13 As far as the Committee is concerned, in their  
14 participation here, we didn't line them up here as a shooting  
15 gallery so you people could shoot at them, but the principal  
16 role here today is to interpret the meaning of the existing  
17 spec, if there is some question about what was intended, as  
18 it stands.

19 And I think, then, beyond that, that perhaps the  
20 Committee will be involved in reviewing the spec as it evolves  
21 into the next phase here.

22 I also would like to ask Dr. Fleischer if he could  
23 sit up at the front table, since he was very instrumental in  
24 forming up this specification. So I'd like to ask him to  
25 come up front.

1 Now I'll turn the meeting back to Jerry Halpert.

2 HALPERT: I would like to make one statement, that  
3 I'm pleased to see all the cross-section of the battery people  
4 here at this meeting; users, manufacturers, and Government  
5 people, in hopes that we would come out with a meaningful  
6 and workable spec that we can all refer to.

7 Now at this point I'd like to describe how we would  
8 like to conduct this meeting. The procedure will be to talk  
9 about the spec only, that is to refer to the paragraph in the  
10 specification, in order, by number. The spec will be pro-  
11 jected onto the screen. We have a projector here. So that  
12 you may not have to refer to your pages. It might be a  
13 lot easier for you.

14 Each man will be given five minutes to discuss the --  
15 or make the statement that he would like to, about the  
16 particular aspects of the specification.

17 All the comments will be read into the minutes of  
18 the meeting, which is being recorded continuously here in  
19 front. We would like to request that no philosophy be  
20 presented. We all know that you have your own ideas of what  
21 a specification should be, and how it should be organized,  
22 the kinds of tests that should be run, the kinds of statements  
23 that should be in the spec. And at this particular point you  
24 can understand that this document was written by people who  
25 have some technical of the field, but not knowledge of

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1 writing specifications.

2 In time, the specification will be modified and  
3 updated, and will be prepared by the proper people, the  
4 specification-writing people and QC people, to be meaningful.

5 We would like your comments to support or criticize  
6 the specification. We have had a number of comments from  
7 the battery companies and others which we will read into the  
8 minutes as we talk about the specific paragraphs.

9 We have had a lot of criticism. We have also had  
10 some supporting comments. If you have a supporting comment  
11 about a particular test, it would help us to know that this  
12 is a meaningful test to you, so that we can make sure that  
13 we do include it in. I think if we were to take every test  
14 in there, we would have criticism about every one of them and  
15 we could throw out the whole thing to start with. So I  
16 think we want to go in a positive direction as well as contin-  
17 uing to make it a better specification.

18 We also request that you do not ask the people  
19 exactly why they put that comment in, or that particular test,  
20 into the specification. There may be reasons which cannot  
21 be discussed -- that is the philosophy behind it. We're  
22 trying to avoid philosophy here. If there is a question  
23 about the meaning of the statement -- in other words, does  
24 one mean you take 50 samples or 5,000 samples, the meaning of  
25 a particular statement, then this would be, certainly, in

1 order to discuss.

2 Microphones are at the sides of the room. We have  
3 two for this particular section of the meeting. We're hoping  
4 to get a couple more. The microphones will have to be passed  
5 around amongst you as you decide that you would like to speak.

6 I will read the comments that we have about the  
7 specific paragraphs into the minutes, and then we will ask  
8 for comments from the floor.

9 Each speaker will be given, as I said, five  
10 minutes, and we have a warning system. We will be keeping  
11 time in case you kind of get long-winded. When the five  
12 minute mark is reached, you'll see an orange light at the  
13 side of the room shown, and if you continue on too much past  
14 that, you will see a red light. And I'd rather not tell you  
15 what that will do.

16 (Laughter.)

17 Are there any questions at this time about that  
18 procedure? For the reporter, please identify yourself clearly  
19 by your last name and the company, your affiliation. It will  
20 be taken down here. And we would appreciate anybody who has  
21 not signed in at the door on that attendance sheet, to please  
22 do so, so we have an accurate record of those who attended.

23 FORD: For the benefit of the people who might be  
24 planning to take notes, you might mention that everything  
25 will be recorded and copies will be available as previously,

1 at the last meeting.

2 HALPERT: Okay. If we can project the first page  
3 up there . . .

4 (Slide.)

5 All right. I won't bother to read these off, because  
6 you can all read. I will only mention the comments that I  
7 have about the particular paragraphs.

8 I do have one about paragraph 1.2. It was suggested  
9 that a standard format be used, and he wanted to speak one  
10 minute on that subject. Where is Mr. Thierfelder?

11 THIERFELDER: My comment was that since we're  
12 attempting to standardize on battery specifications, we should  
13 not lose sight of standardizing on the specification itself.  
14 There is a MIL-STD-490 which spells out the breakdown of  
15 specifications. And I feel it would be a good idea to start  
16 right from the beginning and bring this specification into  
17 a format which has been used by the Government, and break it  
18 down into the standard sections of scope, documents,  
19 requirements, quality assurance provisions and so on, down  
20 the list. An attempt to do this later would only complicate  
21 matters.

22 HALPERT: Thank you. I have no other comments  
23 concerning 1.2 and 1.2.1 or 1.2.2. Does anybody have anything  
24 on those particular areas concerning military specs, federal  
25 specs or publications that should be included in this for

1 reference?

2 Okay, if we can go on to the next . . .

3 (Slide.)

4 1.2.3, Definitions. I do have some comments about  
5 that. 1.2.3.1, the definition of Slurry specifically  
6 includes carboxy methyl cellulose. A general term such as  
7 "binder" should be substituted.

8 The definition of Plaque, by use of the word slurry,  
9 implies that a wet process must be used as a manufacturing  
10 procedure. Therefore, omit "slurry."

11 As written, "Formation" is described as the process  
12 prior to cell assembly when there may be several processes  
13 between formation and cell assembly. Therefore, "formation"  
14 should be described as a process prior to cell assembly.

15 I have no other comments on definitions. Is there  
16 anybody who would like to speak as to the definitions we  
17 used, or would like to add definitions to our list that  
18 appear in this document?

19 Don't be shy, now. We can use all the help we can  
20 get from you people who are the experts.

21 Okay, we'll go on to 1.2.4.

22 FORD: Jerry, may I make a suggestion for the  
23 benefit of the record?

24 HALPERT: Yes.

25 FORD: I have observed that you are reading several

1 comments. Would you, for the benefit of the record, put the  
2 word "comment," then read -- put the word "comment" in front  
3 of each individual comment that you're reading.

4 HALPERT: Okay.

5 (Slide.)

6 All right. We have 1.2.4, Cell Marking.

7 I have a comment here that is marked 1.2.4 (d),

8 "It is recommended that the date of manufacture  
9 should be further defined as the date of activation  
10 of the cell by the addition of the electrolyte."

11 I have a comment about 1.2.5:

12 "It is assumed that alternate methods of such  
13 tests of procedures will be reasonable accepted and  
14 also that a manufacturing proprietary process is not  
15 subject to review. This question of proprietary  
16 processes is one which affects other industries and  
17 should be opened to serious consideration."

18 Any comments from the floor on 1.2.5?

19 (No response.)

20 All right. We go on to 1.2.6 -- I'm sorry, did I  
21 miss somebody?

22 GROSS: Sidney Gross, Boeing. 1.2.4 slipped past  
23 before I could get a comment in -- that the date of manufac-  
24 ture should be considered as the date at which the cell is  
25 sealed, that is, where the top is welded on. This will



1 exclude the possibility of assembling a cell and then keeping  
2 it on the shelf for a year or two before you put the electro-  
3 lyte in.

4 HALPERT: Okay.

5 All right, we finished 1.2.4. Any more comments on  
6 1.2.4?

7 GASTON: Steve Gaston, Grumman. I think it might  
8 be helpful to add that the marking material used show that  
9 out-gas space conditions.

10 HALPERT: Okay.

11 UCHIYAMA: Uchiyama, JPL. My comment is again in  
12 relation to paragraph 1.2.4. It is in relation to the  
13 statement, "The serial number of each cell shall also be  
14 marked on top of the cell. . ." I suggest that the location  
15 of the serial number be left up to the user and the manu-  
16 facturer, because very often in the design of the final  
17 battery, the position of the cell may very well be a very  
18 important factor, to where you may want to put the serial  
19 number for identification purposes.

20 HALPERT: That particular comment was in reference  
21 to 1.2.4.

22 Dr. Fleischer, did you want to say something?

23 FLEISCHER: Does everybody understand that if there  
24 are no comments on the statements that are made from the  
25 floor that they will be adopted? Did you make this clear?

1 HALPERT: No, I haven't made that clear, no. I  
2 would assume that the Committee, when there are no comments  
3 about a specific item in this specification, that the organ-  
4 ization here -- you people who are the experts have agreed  
5 that this is a good idea and we'll accept it as such.

6 If you have a comment about it, it doesn't mean  
7 that that thing will not -- that it will be changed -- it  
8 could still go on to be the same comment, if the Committee  
9 feels such. But at least we will consider your recommenda-  
10 tions about that aspect very strongly, very seriously.

11 BELOVE: Belove, of Sonotone. I understood from  
12 your first remarks, Jerry, that you were going to cut into  
13 the specification and reduce its rather voluminous nature.  
14 Now I think you should elaborate a bit more on that. That's  
15 why I thought nothing much was said here. It's as though we  
16 assumed that this would go into the record as the specifica-  
17 tion of the space batteries, as it sits, with minor modifica-  
18 tions.

19 Now, from what you said at the very start when I  
20 came in, it almost indicated that this appeared to be too  
21 voluminous a specification, and that objections had been  
22 raised from manufacturing sources, and that you were then  
23 going to reduce the size of the specification. Is this or  
24 is it not so?

25 HALPERT: As far as I'm concerned, there is no

1 criteria as to weight or size of the spec. This spec will be  
2 adopted, or at least parts of it, will be adopted as per your  
3 recommendations and the recommendations of the Committee. I've  
4 said nothing about reducing it; I've only said "upgrading it,"  
5 to make the tests in here better suitable and more applicable  
6 to people who do it in the field. If they feel it is not  
7 an adequate test, please tell us -- that another test would  
8 be better.

9 This is what we're doing here. It has nothing to  
10 do with size or organization. We're not talking about organ-  
11 ization now; we're going to do without philosophy.

12 BELOVE: No, no. I'm not speaking about philosophy.  
13 I'm speaking about actual, concrete -- the amount of testing  
14 that's implied and specified in this specification. I thought  
15 that you had implied that because people had objected to the  
16 size of this and the amount of testing, that you were going  
17 to reduce it.

18 I'm wrong. Thank you.

19 HALPERT: Okay. We have had our last comment on  
20 1.2.4. Does anybody have anything to say about 1.2.4, 1.2.5,  
21 or 1.2.6?

22 I have a comment concerning paragraph 1.2.6:

23 "Considering the number of data sheets contained  
24 in the appendix of this document, a real cost impact  
25 is implied."

1 I have not identified the commenters here. If  
2 they would like to say something about their particular  
3 comment, I would welcome that very much.

4 RYDER: I am merely reminding the Chairman that he  
5 did not relate a comment on 1.2.5 which was submitted by  
6 Gulton. My name is Ryder, Gulton Industries.

7 HALPERT: I'm sorry, I think I did read that. Did  
8 I not read 1.2.5? I did read 1.2.5.

9 SCOTT: Scott, from TRW. Excuse me, Jerry. A  
10 point of, I guess, possible clarification of what I gather  
11 was Gulton's response to 1.2.5. I'm wondering if their  
12 comment is implying that they are saying that they reserve  
13 the right to withhold details of any alternate procedures  
14 submitted under the provisions of 1.2.5, if they consider  
15 them proprietary?

16 HALPERT: This is a question concerning the meaning  
17 of a statement, and I would request somebody from Gulton, if  
18 they would, to answer that so that we can clear the record,  
19 about the meaning of that statement. Would you care to make  
20 it, or would you like to put it in at some later time? I  
21 don't want to put you on the spot.

22 PREUSSE: Preusse, Gulton Industries. I think the  
23 statement is pretty clear. Again, when you start asking us  
24 for meanings of statements, it implies the same statement as  
25 needing some comments in the spec. Let's keep this open until

1 later on, okay?

2 HALPERT: Fine. Let's go on, with a note that this  
3 is a comment that should be cleared up at some later date.

4 Now, we have cleared the 1.2 mark. We'd like to  
5 go on to the very next one.

6 (Slide.)

7 2.0. I have a comment from Mr. Reed of General  
8 Electric:

9 "Standardization of cell sizes necessary to  
10 implement detail cell spec." And he said he wanted to  
11 talk one or two minutes. Is he here today?

12 THIERFELDER: He's not here.

13 HALPERT: Did you want to say something about  
14 that?

15 THIERFELDER: No.

16 HALPERT: Okay. 2.1.1. I have a comment:

17 "We cannot use pure nickel strip in the present  
18 sintering equipment."

19 A second comment:

20 "Specification only describes the wet plaque  
21 procedure for making sintered plaques. Sonotone uses  
22 a dry powder method which has yielded successful,  
23 long-life satellite batteries and asks that this be  
24 included."

25 Mr. Belove wanted to say a few words about that.

1           BELOVE: Very few, Jerry. All of us know that there  
2 is more than one method, in fact, I know of two right now, of  
3 making plaques. The specification, however, appears to recog-  
4 nize only one method, the wet, slurry process.

5           It is our believe that the success of some of our  
6 batteries -- and one of them flying on Alouette and Isis --  
7 would indicate that there was some merit to the dry process  
8 too. And so we recommend that the specification be altered so  
9 that the dry method for making plaques, as used by Sonotone and  
10 maybe some others, and which has produced excellent space cells,  
11 be included in the specification.

12           HALPERT: Okay, any other comments? I have one  
13 other comment on 2.1.1:

14           "It is possible that evolution of hydrogen occurs  
15 at the edges of plates made with nickel-plated steel sheet.  
16 However, in our opinion, this situation creates less of  
17 a problem than the use of pure nickel as a support. The  
18 nickel band tends to deform during its pass through the  
19 sintering oven and consequently wrinkled bands and sub-  
20 sequently plates are obtained.

21           "The use of screen as a support presents three dis-  
22 advantages. The first concerns the head of the plaques  
23 which must be cleaned of active material by scraping or  
24 by compression of the sintering. This creates a weak  
25 section on the electrode. The second is that the screen

1. itself can be deformed quite easily compared to a metal  
2 sheet -- actually the edges become quite wrinkled.  
3 Thirdly, when the plaques are cut, there exists at the  
4 edges wires which can lead to short circuits."

5 Now, that's a particular comment about a process,  
6 and I'm not sure whether, after reading the second one here,  
7 that it's applicable to this meeting. The comment was with  
8 regard to a nickel-plated sheet being considered.

9 CARR: Earl Carr, of Eagle-Picher. Jerry, just one  
10 comment. Are we going to discuss the merits of the different  
11 processes, or are we going to discuss the different processes?  
12 I think we ought to all recognize that each process has its  
13 own unique advantages and problems. Eagle-Picher uses pure  
14 nickel screen, we use a dry sintering process, and we have a  
15 quite good space experience.

16 HALPERT: I apologize for that. I left myself quite  
17 vulnerable. I had read it, but that should not have been  
18 included in the minutes here.

19 All right, do you have any other comments about  
20 2.1.1.1?

21 THIERFELDER: I have a question as to why the pure  
22 nickel is desirable?

23 HALPERT: Well, that's correct. I do not wish to  
24 discuss that at the present time. We would consider any other  
25 method, and I do not want to respond for the Committee here as

1 to why a certain thing was chosen. If you do not like it, we  
2 will be very happy to have you take exception to it and  
3 consider that in the writing of the future spec.

4 I have a comment about 2.1.1.2:

5 "Record Hole Pattern. One spiral is 1,000 feet."  
6 It would take one hour and factory personnel, in addition to  
7 what they are presently using to perform that duty.

8 Another comment:

9 "We feel that this paragraph should read, 'The  
10 average size and number of perforations per square foot  
11 of sintered plaque area shall be recorded for each  
12 spiral or impregnation lot.'"

13 I have another comment:

14 "All meshed size should be included in this section.  
15 Also, specification should provide a specified number  
16 with an appropriate tolerance, which applies to the  
17 material in general, and not on a lot-to-lot basis."

18 Are there any other comments about 2.1.1.2?

19 We'll go on to 2.1.1.3. The following comments:

20 "It is difficult to obtain a thin nickel plating  
21 which can be controlled utilizing the ferroxyl test. On  
22 the other hand, if a thick deposit is made, such that  
23 the ferroxyl test is effective, the result is a lack of  
24 adherence of the plating as the band and plaques go  
25 through subsequent heat and mechanical stress during



1 fabrication."

2 I have another comment:

3 "We use a test to control the nickel plating.

4 However, there is not much point in going beyond this,  
5 since when the plate is cut bare iron is exposed on the  
6 edges as well as the impregnation attack on the plate."

7 Another comment:

8 "The question here is, if iron is not a desirable  
9 material in the cell, is the nickel-plating doing the  
10 required job, especially where nickel is attacked during  
11 impregnation process by the acidic nickel nitrate  
12 solution. Also, there is iron exposed when plates are  
13 die-cut to size. Therefore, the significance of this  
14 test is questioned if iron substrate is eventually  
15 exposed."

16 Any other questions about 2.1.1.3?

17 BELOVE: It is our opinion that the substrate should  
18 be pure nickel. One of the reasons -- and there may be others--  
19 but one of the reasons that we see that in processing the iron  
20 may tend to corrode.

21 Now, whether this affects the performance of the  
22 cell or not, is not known for certain. However, we feel  
23 strongly that this is not the way to make a cell for satellite  
24 application, to have materials in it that may tend to corrode.

25 HALPERT: All right. Any other questions?

1 GASTON: Gaston, Grumman. I have a comment on the --  
2 some manufacturers use an edge coating on the negative elec-  
3 trodes. We have examined this carefully and we have seen the  
4 edge coating does come off on sub cells. And it could possibly  
5 cause a failure mode.

6 So I'd like the Committee to consider the edge  
7 coating, and the adhesion of the edge coating in the specifi-  
8 cation.

9 HALPERT: Any other comments with regard to that  
10 statement?

11 Okay, we go on to 2.1.1.4:

12 "Prior to nickel plating the plate is degreased."  
13 That's the only comment I have. Are there any comments about  
14 that?

15 We go on to 2.1.1.1.2. Are there any comments about  
16 2.1.1.1.1?

17 STEINHAUER: Steinhauer, Hughes. Could I make a  
18 general comment concerning these paragraphs that have recently  
19 been brought up? This specification, in a preface, we're  
20 shooting at a five-year or longer cell, and I think some of  
21 these more subtle effects may not be understood for five to  
22 ten-year missions; and what can be tolerable in a, say, one to  
23 three-year, or up to five-year mission, may be different than  
24 a longer mission. And therefore we should entertain comments  
25 on this long-life nicad.

1 HALPERT: Thank you.

2 GROSS: Gross, Boeing. On item 2.1.1.4, a statement  
3 should be included to the effect that the substrate should be  
4 cleaned, and should be clean, prior to impregnation. It may  
5 not be necessary to clean it with degreasing or other methods,  
6 but assurance should be attained, that it is clean.

7 HALPERT: Okay, we're down to 2.1.1.1.1. If there  
8 are no other comments about that, we'll go on to .2. I have  
9 the comment:

10 "Nickel Powder. This involves record keeping on  
11 a batch basis." And it would take 2.5 hours and  
12 additional factory personnel.

13 Another comment:

14 "Another important parameter is the bulk density  
15 of the nickel powder, since it affects compaction and  
16 therefore porosity and pore size distribution of the  
17 plaque. This is true whether wet or dry method for  
18 plaque manufacture is used."

19 Any other comments about that paragraph, .2?

20 CARR: Just one comment, Jerry, and that is that in  
21 places where we talk about a certified analysis, I just want  
22 to mention that that's a cost item, and it should be considered  
23 as such by the Committee. If they want 100 percent test, fine.  
24 It's just a cost item.

25 HALPERT: Any others about .2? Mr. Gross?

1 GROSS: Gross, Boeing. The items that are in the  
2 analysis should be specified. For example, particle size might  
3 be quite important.

4 KIRKENDALL: Kirkendall, COMSAT. I believe there's  
5 a need for clarification of the numbering of the paragraphs.  
6 In this 2.1.1.1.1, it implies it's a sub-category of 2.1.1.1.

7 BILLERBECK: Indeed. We have a numbering problem  
8 there. It should be 2.1.2 - Slurry.

9 HALPERT: Yes.

10 KIRKENDALL: Subsequently there will be a revision  
11 on all remaining numbers?

12 HALPERT: Okay, if there's no more about .2, we'll  
13 go on to .3, and hopefully we can pick up a little speed here.

14 Comment:

15 "This involves record keeping on a batch basis,"  
16 which will take 2.5 hours and additional factory personnel.

17 Another comment:

18 "Rather than designate the binder as carboxy methyl  
19 cellulose, this should be left open and should be  
20 determined by the manufacturer of the cells. However,  
21 regardless of the binder, we are in agreement with the  
22 traceability which is called out."

23 Another comment:

24 "This paragraph is restrictive in that it specifies  
25 a particular binder or thickening agent, when general

1 terminology should be used."

2 Any other comments about .4?

3 FLEISCHER: If we include the term "binder," instead  
4 of a specific material, we should add a definition for binder,  
5 so that it's understood exactly what its function is.

6 HALPERT: Any other comments about .4?

7 MAURER: Might I suggest that in the place of  
8 carboxy methyl cellulose, you just say "other slurry ingred-  
9 ient," and scratch out the next section, .4, so that you have  
10 all these factors on all the other ingredients besides nickel?

11 HALPERT: All right. We go on to .5.

12 Comment:

13 "This would add to the slurry cost."

14 Another comment:

15 "The measurements of pH can be inaccurate and  
16 misleading in mixed solutions, and therefore may not be  
17 a useful measurement, depending on slurry formulation."

18 Any other comments on .5? If I don't see you, please  
19 shout out, because it's kind of hard to see everybody out  
20 there.

21 All right, 2.1.1.1.6 -- I'm sorry, there's one on  
22 .5 I missed:

23 "The measurements called for should be made just  
24 prior to use."

25 Now we go on to .6.

1 "Record keeping and testing one hour per spiral.  
2 The continuous gas analysis impracticable, and we know  
3 of no equipment that can do it."

4 That's 2.1.1.1.6. Another comment:

5 "The measurement of the influent gas is more  
6 critical since it is the environment to which the  
7 plaque is exposed. The effluent gas is after the fact  
8 and is not an effective control point. Also, the  
9 furnace temperature profile should be measured prior  
10 to plaque sintering, since the temperature operation is  
11 both time and temperature-dependent."

12 Any other comments about .6? Yes, sir?

13 CARR: Just a definition,, Jerry. Carr, Eagle-Picher.  
14 It says that the temperatures of the different chambers of  
15 the furnace should be monitored continuously. Does this mean  
16 a continuous recording type temperature device?

17 HALPERT: That's right. That's what it was intended  
18 for.

19 Okay, we're down to 2.1.1.1.7, rate of travel of  
20 substrate.

21 There was additional effort involved with rate of  
22 travel of substrate.

23 We'll go on to .8. Comment:

24 "Again the term spiral is used in this paragraph.

25 We recommend that for this particular and all following

1 cases whenever reference is made to a spiral, that in  
2 fact, either spiral or an impregnation lot should be  
3 called out."

4 Another comment:

5 "The term 'spiral' infers a given processing method,  
6 and should be given a more general term such as 'plaque  
7 lot.'"

8 Any others on .8?

9 Okay, go on to .9. Comment:

10 "We disagree with the necessity of recording  
11 coining pressure since the coined area thickness is a  
12 dimensioned thickness. This should be sufficient, as a  
13 control in defining the plates."

14 Another comment:

15 — "Coining can be, and has been performed, after the  
16 formation process; independent of which method is used,  
17 the coined thickness should be monitored since it reflects  
18 directly the amount of compaction, i.e., percent reduc-  
19 tion, that the sinter has undergone."

20 Another comment:

21 "If each size plate is coined, it will require a  
22 complete set of coining dies. It would eliminate the  
23 special capacities required by many customers. In many  
24 instances these special capacities are required for a  
25 weight reduction. It sounds impractical to us to make

our standard cells because of the additional cost of the dies."

All right. Any other comments on .9?

2.1.1.1.10. Comment:

"This is unacceptable under the present process. We must compact in some cases."

Another comment:

"This paragraph is contrary to present practices, and we would prefer that a tolerance be placed on the amount of compactness rather than complete denial to the present method of production."

Any other comments about .10? Yes, sir?

THIERFELDER: Going back to .9, according to your definition of plates, that should be plaques -- in 2.1.1.1.9.

HALPERT: Yes. That should be plaques. Thank you.

All right, do we have any more on .9 or .10? Any comments, questions? No questions. All right.

Going to the next, which is 2.1.2.1. I have a comment:

"Plaque Samples. We would lose 41 plates out of each 1000 feet, and it would require one man continuous."

Another comment:

"The measurement of plaque samples should occur at reasonable intervals to assure control of plaque uniformity. The samples should be taken at 25 foot intervals or every



1 thirty minutes, whichever is smaller. Also, samples  
2 taken across the width of the plaque should be sufficient  
3 to assure uniformity of thickness and plaque weight.  
4 Samples should be taken across the plaque width in the  
5 quantity of one inch of sample per two inches of plaque  
6 width."

7 One more:

8 "It would be advantageous under our present method  
9 of production to take the plaque samples from the  
10 beginning, middle and end of an impregnation lot, after  
11 which the test recommended in 2.1.3 could be run."

12 BELOVE: Belove, Sonotone. Again, here is a  
13 possible advantage of the dry, slurry method, in that in the  
14 dry, slurry method, each and every plaque -- not pieces of  
15 it -- but each and every plaque is weighed, and can be weighed  
16 and all properties recorded.

17 HALPERT: Okay. I have a general comment concerning  
18 the next couple of paragraphs:

19 "In view of the plaque and plate sorting which we  
20 recommend in our discussion of paragraph 2.4, we do not  
21 think it is necessary to test as many samples per spiral  
22 as indicated in 2.1.2.1. This comment is primarily  
23 made regarding the porosity spectrum analysis because  
24 of its rather high cost. We believe that with the same  
25 lot of slurry, the same thickness and the same weight,

1 which should be continuously controlled, the global  
2 porosity is constant and the distribution of pores  
3 does not vary a great deal. We recommend that this  
4 contention be verified in an initial qualification  
5 study (process qualification). Actually, we believe  
6 that during production, only one or two control samples  
7 per lot of slurry will be found necessary."

8 Any other comments about 2.1.2.1?

9 Okay, on we go. 2.1.3.2 is my next comment. Did  
10 anybody have anything before that? I guess there's nothing,  
11 really.

12 2.1.3.2 is the next one.

13 "41 samples per 1000 foot of spiral would be  
14 required."

15 Another comment:

16 "This frequency of measurement of porosity and  
17 pore size distribution should not be necessary if  
18 sintering furnace temperature and profile are stable.  
19 Thickness and weight per unit area measurement are  
20 normally sufficient if the temperature time cycle is  
21 predictable."

22 Any other comments about 2.1.3.2? Okay, we go on  
23 to 2.1.3.3. Comment:

24 "41 samples per 1000 foot of spiral would be  
25 required."

1 Another comment:

2 "In this case, the element to be analyzed for  
3 should be stated with the required accuracy and precision.  
4 Other methods for analysis are available and are  
5 easily handled by trained personnel. For example,  
6 induction furnace and absorption train."

7 Another comment:

8 "We have the same remark as above for the carbon  
9 content analysis. In production, one sample for each  
10 lot of slurry should be sufficient."

11 I have another one with regard to -- no, I'm sorry.

12 2.1.3.4 is the next. Anybody have anything on .3?

13 Okay. .4: Comment:

14 "It would be necessary to develop this test which  
15 does not"-- yes, I'm sorry. Go ahead.

16 CARR: This is regarding the carbon test on .3.

17 Carr, Eagle-Picher.

18 We use a dry process also, and we don't feel that  
19 the tests on carbon are necessary in a dry process.

20 HALPERT: Going on to .4 -- anything else on .3?

21 2.1.3.4. Comment:

22 "It would be necessary to develop this test which  
23 does not presently exist at this company. The test  
24 which we use is quite different in that it measures  
25 the force necessary to push a needle through the plaque

1 at one of the perforations in the band. However, because  
2 all results of sintering strength are in general quite  
3 dispersed, we believe it is a good idea to increase the  
4 tests so as to have a better average value."

5 Again, comment:

6 "41 samples per 1000 foot of spiral would be  
7 required."

8 Does anybody else have anything on 2.1.3.4?

9 STEINHAUER: Steinhauer, Hughes. If the spec is  
10 broadened to include the dry process, I think there should be  
11 applicable paragraphs as an alternative for slurry. In other  
12 words, there's nothing specifying a dry process and the controls  
13 that would be needed at this point for that.

14 HALPERT: Did you want to say something about --

15 BOGNER: Bogner, JPL. You're asking for a lot of  
16 measurements and requirements here. Do you have -- does  
17 anyone have any specifications to put on what these requirements  
18 should be? Maybe that's an approach to take.

19 HALPERT: I'm not going to answer the question. We  
20 will consider that, as far as the Committee is concerned.

21 Don, did you want to make a comment about mechanical--

22 VOICE: I just wondered if there was any question  
23 as to the -- relevant to doing strength tests and things like  
24 this. If there's no question about it, there's no need for me  
25 to make any comment.

1           While I'm talking, there is one thing between this  
2 general section and the next one. There doesn't seem to be  
3 any specification as to how the plaque should be stored, in  
4 what condition that should be kept. There is quite a bit  
5 on plate storage, but not on plaque storage, between sinter-  
6 ing and impregnation.

7           HALPERT: Any other questions or comments on .4?  
8 Yes, sir?

9           GROSS: Gross, of Boeing. There's no criteria for  
10 success or failure.

11          HALPERT: Anybody else, on .4? Okay, I guess we'll  
12 go on to the next page. This is 2.2.1.2. Any comments on  
13 2.2.1.1? All right, we'll go to .2:

14           "At the present time we use special controls for  
15 the impregnation of spirals for space plates; however,  
16 at the same time, in the same tank, we impregnate  
17 spirals for commercial use. Because of the size of the  
18 impregnation tanks, it would be necessary to have an  
19 order for space cells requiring some large number of  
20 meters of plaque in order to comply with this paragraph."

21           Any other comments on 2.2.1.2? Okay, we'll go on  
22 to 2.2.1.3. Comment:

23           "At the present time we take periodic samples  
24 during the number of cycles of impregnation, but not  
25 from each cycle as indicated. We question whether or

wel 35

1 not the high expense for analyses is necessary."

2 All right, that's 2.2.1.3. Any other comments  
3 about that. That was .2.

4 2.2.1.3. Comment:

5 "Analyzing the impregnation bath would mean the  
6 24 separate baths would have to be analyzed per spiral."

7 Another comment:

8 "The type and acceptable level of impurities should  
9 be stated. Also control levels and tolerance of pH on  
10 concentration should be stated. Density is not an  
11 accurate value for control of solution, and analytical  
12 techniques are available for bath control. Analysis of  
13 rinse bath is questioned since it is the end of a  
14 production stream and cannot be used as a control measure-  
15 ment."

16 Any other comments about .3? You all like it?

17 CARR: Carr, Eagle-Picher. We're just being quiet  
18 when we agree with some of the other people's comments.

19 On the impurities in the cobalt concentration in  
20 particular, we feel that this needs a better definition and  
21 it's certainly not the type of thing that we'd check each  
22 cycle. The other items, we generally check each cycle.

23 HALPERT: Any other comments? All right, we'll go  
24 on to .4. Comment:

25 "We do not use potassium hydroxide. This would

1 require a complete new set up which we cannot make.  
 2 The present process uses sodium hydroxide rather than  
 3 potassium hydroxide and unless reason can be given for  
 4 the change, exceptions are taken to this paragraph."

5 Another comment:

6 "We question the exclusive use of KOH  
 7 processing of nickel-cadmium plates."

8 Any other comments about .4? I think there's a  
 9 general opinion about that, isn't there?

10 Another comment:

11 "A precipitation solution of KOH has two disadvan-  
 12 tages. First, the price of KOH is three times that of  
 13 NaOH. Secondly, with present equipment, 4 impregnation  
 14 tanks are supplied by a common reservoir that presently  
 15 utilizes sodium hydroxide. To change to KOH for just  
 16 space plates would be impractical. Separate impregnation  
 17 equipment for space cells would have to be installed if  
 18 KOH is definitely required.

19 "In the course of our studies for the development  
 20 of space cells, we have conducted special tests to  
 21 determine the effect of sodium hydroxide versus KOH as  
 22 the precipitation solution. The results indicate no  
 23 difference in the characteristics of the cells.  
 24 Therefore, we recommend that the precipitation solution  
 25 should be left optional as KOH or NaOH."

1 Any other comments?

2 FLEISCHER: I think at this point it isn't the  
3 potassium hydroxide or sodium hydroxide that is important, but  
4 the specification for it. In other words, you could use the  
5 crudest kind of sodium hydroxide if it isn't defined and  
6 included here.

7 HALPERT: Okay. Any other comments regarding .4?  
8 Yes, sir.

9 BELOVE: Belove, Sonotone. Dr. Fleischer brings up  
10 a point of impurities, and if I want to stretch a point here,  
11 I can say then why introduce any impurities into this, and  
12 let's go back to the wet slurry process. We're introducing  
13 carbon, we're introducing a carboxy methyl cellulose; let's  
14 give some thought to this. If we're going to keep it pure,  
15 let's give some thought to the other methods whereby this can  
16 be accomplished. Thank you.

17 RUBIN: Rubin, of Texas Instruments. After quite  
18 a bit of research we found out that the use of potassium  
19 hydroxide in the impregnation or formation procedures would  
20 essentially lower the coefficient of utilization of the nickel  
21 hydroxide. So therefore, it is unwise to use potassium hydrox-  
22 ide, and it's basically a chemistry effect. The sodium has  
23 to enter the lattice, and it has some substantial chemistry  
24 effects in it.

25 HALPERT: Any other comments regarding .4?



1 FLEISCHER: I'd just like to answer the statement  
2 before, by Lou Belove. I think the use of carboxy methyl  
3 cellulose or any other binder in the process should not be  
4 defined as an impurity, because if you do that then we have  
5 to look at the nitrate, which can be far more effective as  
6 an impurity if you leave it in, if your processing isn't  
7 correct.

8 So, in terms of impurity, we mean those things  
9 which are harmful to the operation of the cell. And I think  
10 we shouldn't get into a debate about this. The processing  
11 eliminates nitrate, and it will eliminate the carbon compounds  
12 that you use as binders, if you choose them properly and if  
13 you treat them properly.

14 HALPERT: Okay, thank you.

15 BELOVE: I don't agree here that this nitrate  
16 question isn't an important one. You say, yourself that  
17 nitrate may be an impurity. Now, carbon can also be a  
18 certain impurity. To this extent, all these extraneous  
19 materials can be considered undesirable. To the same extent  
20 that you want pure chemical solutions.

21 HALPERT: I'd like to cut off that type of comment,  
22 because that isn't at the moment helping the specification.  
23 I think we know what you intended, and I think we know what  
24 Dr. Fleischer intended. And the Committee will then utilize  
25 those statements to come up with something meaningful.

1 All right. Let's go on to 2.1. -- I'm sorry --  
2 anybody else? Yes, sir. I'm sorry..

3 NIETZEL: Nietzel, T.I. I'd just like to make one  
4 statement about carbon content. I think you'll find that  
5 under the proper sintering conditions the carbon content of  
6 the resulting plaque will be lower than the carbon content  
7 of the material that went in. I'm talking about powder and  
8 screens.

9 FLEISCHER: I'll add a statement to that, just so  
10 that we're clear. Providing you do the sintering in hydrogen  
11 atmosphere.

12 NIETZEL: We do not use hydrogen.

13 FLEISCHER: And you can get the carbon down lower?

14 NIETZEL: That is correct.

15 HALPERT: Can we go on to 2.2.1.5? Is there any  
16 other comment about .4 now? Regarding the specification,  
17 please.

18 Okay, .5. Comment:

19 "Record keeping is all that is involved here."

20 Another comment:

21 "The stated method of control and measurement is  
22 inadequate. The number of impregnation cycles can  
23 vary appreciably, depending on the method of plaque  
24 manufacture, as well as the impregnation techniques.  
25 Therefore, the number of these cycles is of use for a

1 given manufacturer and may not be readily compared to  
2 other processes. To determine the necessary attributes  
3 for controlling the impregnated plate, weight gain data  
4 is insufficient and misleading. This measurement in no  
5 way corrects for plaque corrosion which varies measure-  
6 ably between positive and negative plates, (and process  
7 to process) and in no way can measure the degree of  
8 plaque corrosion which affects the ultimate strength  
9 of the plate substrate. To determine the quantity of  
10 active material, present and converted and/or formed  
11 plates, precise analysis including one sinter weight  
12 per unit area before impregnation, substrate weight per  
13 unit area before impregnation, sinter weight per unit  
14 area after impregnation, plate weight per unit area  
15 after impregnation, quantity of nickel, cobalt, cadmium  
16 hydroxides and/or metals present, must be performed and  
17 documented. Using this type of analysis, actual active  
18 material measurements can be made."

19 Do you have any comments about .5?

20 GASTON: I think it is intended here in all the  
21 records which are being kept, that the day for the various  
22 processes and steps which are conducted, should be added.  
23 It isn't specifically called out. It might be of importance  
24 to know when each specific test was conducted.

HALPERT: Okay. Any other question about .5?

1 We'll go on to .6, then. Comment:

2 "We wash and dry the impregnated plaque while still  
3 in spiral form and not after being cut into plates."

4 Another comment:

5 "Drying in an inert atmosphere at less than 80°C.  
6 can be both costly and time-consuming. Since air is  
7 used at the present time, the reason for a change from  
8 air to the inert atmosphere should be substantiated."

9 Another comment:

10 "Not all processes dry plates between impregnation  
11 and formation. Therefore, drying should not be  
12 specified. Also, the pH of the rinse water as specified  
13 is lower than can be expected, based on solubility of  
14 both nickel hydroxide and cadmium hydroxide."

15 Any other comments about .6? Okay, we go on to

16 2.3.

17 I have a comment on 2.3.1:

18 "If a plastic material is used in the packaging of  
19 the plate material, it should be chosen carefully so  
20 as not to contain any contaminants."

21 Any other comments about .1?

22 CARR: Carr, Eagle-Picher. Have we established  
23 the absolute necessity for inert gas filled shipping contain-  
24 ers, rather than a sealed container?

25 HALPERT: It hasn't been established, if that's

1 what you're asking.

2 CARR: I think it ought to be considered by the  
3 Committee that inert gas filled containers is a cost item.

4 HALPERT: Okay, 2.3.4 -- we're down now to .5.

5 (Slide.)

6 Comment:

7 "Since considerable care is required in the packing  
8 and storing of plates, the six-month limit noted in  
9 this paragraph should be justified on a technical basis."

10 Any other comments about .5?

11 CARR: I didn't understand that. What was that  
12 again?

13 HALPERT: "Since considerable care is required in  
14 the packing and storing of plates, the six-month limit  
15 noted in this paragraph should be justified on a  
16 technical basis."

17 That's the comment to the Committee about this.

18 Any other comments about .5?

19 CARR: I have a comment regarding 2.3.2. Do we  
20 have to use white gloves?

21 HALPERT: Okay, any other comments? All right, I  
22 think at this particular point we can all use a break, and  
23 I understand there is coffee waiting in the wings at the top  
24 of the stairs. So we'll return in 10 to 15 minutes.

25 (Recess.)

1 HALPERT: All right, gentlemen, first I think if  
2 there is no objection, we may do without this projection on  
3 the screen. You have a copy of the spec. Does anybody really  
4 object to not using the screen?

5 (No response.)

6 Secondly, I might say that the manner in which  
7 we're going through this is not specifically to keep it on a  
8 time basis. The time is not the important thing here, although  
9 we would like to keep it in a reasonable time limit.

10 The important thing here is to get comment -- receive  
11 comment from you, the experts, on how we can handle our  
12 process and specifications we're talking about.

13 I'm going to apologize here for a moment, because  
14 I've tended to cut some people off. I didn't really mean to  
15 do this. I'd like to stimulate the discussion, but keep it  
16 on a technical basis. If you have a good comment, please  
17 speak up. It would help us immensely. We're only eight people  
18 here, representing the whole industry, and you people, many  
19 of you, know quite a bit more about it than we do.

20 So if you can possibly help us, we're asking for  
21 your help. And don't be afraid to get up and say something.  
22 I'll try to go a little slower so it will give you the chance  
23 to think about it a little bit.

24 Thirdly, at the end of this particular session if  
25 we do have some time before lunch, I would like to possibly get

1 into maybe a little bit of the philosophy or a little bit more  
2 of the background, if you care to make some general comments  
3 about. I think, hopefully, we'll have a little bit of time.  
4 If we don't have by the end of this session, we certainly hope  
5 to have by the end of the two-day session, to discuss this  
6 philosophy and the background and make some general comments  
7 about the whole thing.

8 So please don't hesitate, and I'll try not to cut  
9 you off. But please make the comments pertinent and to the  
10 general specification. At least the technical aspects of it.

11 Okay. We're down to 2.4. Plate Quality Tests.

12 My first comment is regarding 2.4.1.1:

13 "Although extreme care could be taken to prevent  
14 a rupture or cut to the storage containers, it is still  
15 possible for such to happen. It does seem, however,  
16 almost punitive to reject a group of plates because of the  
17 opening of their storage container. It would seem that  
18 subsequent tests would certainly determine whether these  
19 plates were in fact damaged."

20 Okay, is there a comment in that regard? At the sides  
21 of the room we have some people, Jim Stemmler and Ed Colston,  
22 who will be glad to pass the microphones in so you don't have  
23 to walk out to the edge.

24 MC CALLUM: McCallum, from Battelle. I wanted to  
25 comment on 2.4, where I see the word "quality" in there twice.

1 It's also back at the beginning of section 2.0. The name of  
2 this document has to do with the reliability, and I think both  
3 of those words either ought to be defined, or if they're syn-  
4 onymous, I would suggest that you eliminate the word "quality"  
5 and use the word "reliability," because reliability, I under-  
6 stand has a very precise meaning. Quality does not.

7 HALPERT: Okay, there was another one back in there  
8 somewhere?

9 CARR: Carr of Eagle-Picher. Regarding 2.4.1.1.,  
10 I would think that MRB action would be appropriate for judgment  
11 of damage.

12 HALPERT: What was that? I'm sorry.

13 CARR: Materiel Review Board action.

14 HALPERT: Any other comments regarding this?

15 Okay. I have none on 2.4.1.2. Does anybody have  
16 anything on .2? Questions, comments?

17 (No response.)

18 Paragraph 2.4.1.3. Comment.

19 "Because of the requirements for visual defects or  
20 cracks, et cetera, shown in 2.4.2.2, it would seem that  
21 at least a double number of plates normally required  
22 would be necessary, and therefore, the sample size would  
23 have to be correspondingly increased."

24 Any comments on -- let's see -- I have one more on

25 BOGNER: Bogner, JPL. I'd say it would depend on the



1 cell design, the number of sample plates.

2 VOICE: I believe that sampling inspection can't be  
3 used for these plates. With the long-life objectives, I think  
4 every care should be taken to assure that each of the plates  
5 used is at its best level of quality. And in order to achieve  
6 this, I recommend 100 percent inspection.

7 HALPERT: Any other comments about that? I might  
8 say one thing regarding this aspect. What we are trying to  
9 do here is set up a way in which we could inspect -- that is,  
10 take a sampling of the plates to see whether -- in other words,  
11 accept the plate batch lot; but that ultimately, all plates  
12 would be inspected.

13 In the next section -- section 5, I think it is,  
14 where we assemble the cells, that all the plates would be  
15 100 percent inspected at that time. This would only accept  
16 the lot, and all the measurements would be made on that sample,  
17 the 80 or so that I give as an example in here. That is the  
18 purpose of this particular section, or what was intended.

19 CARR: Carr, Eagle-Picher. I agree, Jerry. I think  
20 there should be 100 percent inspection on plates, and I agree  
21 that there should be a sampling plan on plate lots. I think  
22 the sample size is somewhat excessive.

23 YERKES: Yerkes, Heliotek. I think maybe there's  
24 some confusion here.--it might be on my part -- about the  
25 reference of this specification. It seems to me this is

1 written for the customer, who is going to buy some plates or  
2 cells from somebody, and the manufacturer may want 100 percent  
3 inspection. But we don't want to compound this in any aero-  
4 space product -- it's a common problem -- it gets inspected,  
5 inspected, inspected.

6 So you may do 100 percent inspection, but then when  
7 you buy them off, there may be a sample which just keeps you  
8 honest. Is that the intent of this?

9 HALPERT: Right. The first, of course, for the  
10 plates, would be the sample of plates from that particular  
11 batch would be inspected to determine whether there is accept-  
12 ability of the entire lot. If there were acceptability of the  
13 lot, then we would go downstream and when the cells were  
14 actually assembled, or put into a formation process, they  
15 would then be -- that is, every plate in the whole lot, not  
16 only the sampling procedure, but every plate in the whole lot --  
17 would be accepted, to make sure that it would be adequate.

18 So -- is that what you're saying?

19 VOICE: The specification does not say that later on  
20 each of the plates will be inspected. In all of section 2.4 --  
21 it begins with a discussion of sampling -- pardon me, 2.4 and  
22 some of the preceding sections -- talk only of sampling.  
23 There's no provision here, as I have the spec here, that  
24 provides for 100 percent inspection later on.

HALPERT: 7.2.2.4 would spell that out. And that will

1 be discussed at a later time, when Floyd Ford, who wrote that  
2 particular section -- right here, all we're doing now is  
3 accepting the lots, really, based on a sample of the particular  
4 batch.

5 GROSS: Gross, Boeing. The need for the number of  
6 tests on samples should be determined by statistical means.  
7 In other words, if weights of plates, for example, are consist-  
8 ently well within the tolerances, then the statistical require-  
9 ment for the number of samples to be weighed is less.

10 HALPERT: Any other comments regarding that particular  
11 aspect? Yes, sir.

12 BILLERBECK: I think that's a good general comment  
13 on the spec, that perhaps many of these tests should be done  
14 in the way that one normally does with these sampling tests.  
15 So that if you find a large percentage are not meeting the  
16 requirements, then you go to a larger sample size. And I  
17 think that would be a good way to arrange many of the tests in  
18 the specification.

19 HALPERT: I'll read an additional comment which I  
20 have here, which I missed at the time, which I think is  
21 directed at this:

22 "General comment on the sampling control procedure  
23 outline: We believe that without initial sorting of the plates,  
24 it would be impossible to meet the criteria of 2.4.2.6 (2.5  
25 percent maximum reject). We recommend that a sorting procedure

1 be included in which all the plates are examined from the stand-  
2 point of appearance, weight, and thickness. Those plates pass-  
3 ing the requirements would then form the lot from which samples  
4 are taken. The inspection of the samples would then serve to  
5 verify that the sorting was well done. Relative to appearance,  
6 color standards are very difficult to establish because of the  
7 effect of age. This item, therefore, should be analyzed further.

8 I think this is a little bit further down. I think  
9 this regards this whole section. I'll just go on reading it,  
10 and then we can go on and cover the items one by one.

11 "Regarding visual defects, in our present procedures,  
12 which have less severe criteria for acceptance than this  
13 specification, a certain percent of the plates are rejected in  
14 sorting.

15 "Considering dimensions, our experience has shown  
16 that the standard distribution of thickness is in the order of  
17 greater than plus or minus 1 mil. The rejection rate will be  
18 extremely high. Finally, since the standard. . ." -- I'm sorry,  
19 cross out the word "extremely."

20 ". . . would be high. Finally, since the standard  
21 distribution in weight is (a given figure) a tolerance of plus  
22 or minus 0.1 grams would result in a high rejection rate.

23 "The above comments are made to point out that from  
24 the standpoint of cost, the critical requirements of these  
25 paragraphs should be verified for necessity. Also, relative to

1 the weight requirement, because of differing sizes of plates,  
2 we suggest that this limit be expressed as a percentage rather  
3 than as a fixed plus or minus 0.1 gram, regardless of size."

4 Those are some general comments about that whole  
5 section, 2.4, and I will now go to 2.4.2 if there are no  
6 further comments about that.

7 "Sample inspection should be carried out either  
8 before storage or on receipt."

9 2.4.2.1. Comment:

10 "The establishment of color standards is rather  
11 unique in this business. Merely to reject plates because  
12 of variation in color, without determining whether it is  
13 a chemical or electrical performance problem, is to  
14 reject because of lack of knowledge rather than for real  
15 cause."

16 Okay, any comments with regard to 2.4.2.1?

17 FORD: Jerry, I'd like to ask a question in regard  
18 to the manufacturers' representatives here. Do any of the  
19 manufacturers at this time have any of their own color standards?  
20 Without elaborating on what they are -- a simple yes or no  
21 would be sufficient in this case. Have they adopted some type  
22 of color determination in screening plates for aerospace use?

23 (No response.)

24 I assume no answer will mean all of it is "no."

25 HALPERT: Okay, any other comments with regard to .1?

1 All right, we'll go to .2. Comment:

2 "The reject criteria shown in paragraph 7.2.2.4  
3 seems extraordinarily tight. Can the limits set in  
4 this specification be technically justified? It must be  
5 remembered that the product is a sintered nickel product  
6 and not machined or honed."

7 Any other comments about .2?

8 We go on now to .3. Comment:

9 "The thickness tolerance of plus or minus 1 mil is  
10 technically unjustified and impractical. The same  
11 comments are for the length and width variation of plus  
12 or minus 5 mils."

13 Any other comments regarding .3?

14 2.4.2.4. Comment:

15 "The plate weight variations should be given as a  
16 function of plate area or plate weight."

17 Another comment:

18 "Variations in plate weight depend on plate size  
19 and should not be expressed in an absolute quantity. A  
20 standard deviation expressed as a percentage may be  
21 used. Also, the absolute value expressed here, .1 gram,  
22 is much too low and conflicts with the thickness tolerances  
23 allowed in 2.4.2.3, that is, a thickness variation of  
24 approximately 1/30th, while the weight variation is  
approximately 1/300th. So that there is an order of

1 magnitude difference in the allowed variation."

2 I might just say that was a mistake, but most people  
3 did comment on that particular aspect -- that is, using a  
4 given value of .1 gram, rather than a percentage. And I'm  
5 glad that we were all awake to find that. That shows you're  
6 all doing your homework.

7 Does anybody want to comment now on any of that  
8 section up to 2.4.2.4?

9 Okay then, we go to .5 -- no, .6 is the next one.  
10 Any comments on .5?

11 All right, 2.4.2.6. Comment:

12 "Because of the limits set in this specification,  
13 we would prefer to run a 100 percent inspection on plates  
14 and reject those with defects. We do not agree to any  
15 total rejection of either a spiral or impregnation lot."

16 CARR: Which section are you on, Jerry?

17 HALPERT: 2.4.2 -- anywhere up to --

18 CARR: Well, regarding X-ray of plates, this is a  
19 tough procedure at best, and we don't do it on a 100 percent  
20 basis.

21 FORD: Does that imply you do it on a sample basis?

22 CARR: No.

23 (Laughter.)

24 HALPERT: I might make a comment about that. Al-  
25 though it says a 100 percent inspection -- 100 percent X-ray

1 diffraction, in all of these cases we mean of a certain given  
2 sample, a fraction of a certain given sample, which is a sample  
3 in itself. But we don't expect everybody to take 1,000 plates,  
4 if that's the number involved, and X-ray them all to determine--  
5 this is a -- in this particular section we've taken a sample  
6 from the original batch, divided that into certain parts,  
7 and of the certain parts we would ask for that -- suggest that  
8 that type of treatment be given. That is not a 100 percent  
9 inspection, and none of these represents a 100 percent inspec-  
10 tion of every single plaque in -- plate in the batch.

11 BELOVE: Is it cause for rejection? And if so,  
12 what percentage?

13 HALPERT: We weren't going to bring up this point  
14 until later on, but as you notice in here, we have very few  
15 limits in terms of the actual processing. We do not know the  
16 limits. We are trying to find out what those limits should be.  
17 We are really asking for data at this particular time, to  
18 establish some ground rules so that we can say your particular  
19 process should be between these limits, and your particular  
20 process should be between those limits.

21 And we know if we get a batch that is not within  
22 those limits, that we know that something is wrong and we can  
23 reject.

24 At the moment we don't have those figures, so if  
25 you were to get a job today we could not reject it, based on



1 that kind of number.

2 RICHARDSON: Richardson, Marshall. In regard to  
3 these breaks or cracks in these plates here, I think before  
4 you'd want to call out X-ray or radiographic inspection of any  
5 of these plates, I think first you've got to establish the  
6 criteria for the cracks. Can you stand a crack 100/1,000th  
7 long, you know, or is the crack completely across the plate?  
8 I don't know what benefit you'd get by just X-raying these  
9 sample plates. If you'd find cracks, how do you know that  
10 they're bad or good? How do you know whether they'd hurt you  
11 or not?

12 So, just to be radiographic plates, and for possible  
13 rejection of the sample lots -- I don't know. I think you  
14 need a study program or something like this, to determine what  
15 length of crack you can stand. Because I doubt if you'd ever  
16 find -- I don't know.

17 HALPERT: Actually, lengths of cracks are spelled  
18 out a little later on.

19 REED: Reed of Battelle. If I read this specification,  
20 2.4.2.5 correctly, "the substrate for the sintered material"  
21 means the perforated foil. I wonder if this is the place to  
22 check it for cracks? Shouldn't this have been done way back  
23 before the slurry or dry powder was ever put on? And if this  
24 is done, do you really expect it to crack later on during the  
25 process? It might be possible that the sintered material cracks,

1 but I question whether the foil would crack.

2 HALPERT: Good point. Any other comments regarding  
3 that?

4 All right. I have no other up through the end of  
5 2.4.2.8. Does anybody have any comments regarding .5, .6, .7,  
6 or .8?

7 CARR: Again, Jerry, I think a materiel review board  
8 would be a thing to be considered before you reject an entire  
9 lot.

10 HALPERT: Would you describe what you mean by that,  
11 and how it would be -- would that be in a given company, or --

12 CARR: In producing quality batteries, our experience  
13 at Eagle-Picher is that we have, with certain customers, the  
14 material review board authority. And what this is that we  
15 have a board, a panel of people, representative of production,  
16 engineering, quality, the vendor representative of the company,  
17 and the government inspector where it's required on the  
18 contract. These people judge the defect and say that it can  
19 be used or it can't be used, and then determine corrective  
20 action.

21 VOICE: Earl, is this MIL SPEC-9858 a -- I think it  
22 is --

23 CARR: Probably is, but I'm not sure. .

24 VOICE: I think we ought to institute that spec on  
25 setting up the quality.

1 CARR: MILSPEC Q-9858-A.

2 VOICE: It's a quality spec.

3 RICHARDSON: We prefer 200-3 or 200-2.

4 (Laughter.)

5 There might be some, just general.

6 NIETZEL: The MILSPEC does have it.

7 HALPERT: That is an area that we certainly could  
8 look into, and I think the specifications people will be -- it  
9 will be helpful in that area, to guide us, on which general  
10 specs and whether it be a NASA spec or a military spec or  
11 what have you. The military would like military specs and  
12 I'm sure NASA people like NASA specs.

13 GREEN: Green, Martin - Denver. On 2.4.2.5, I  
14 notice you're determining X-ray or radiographic techniques.  
15 Are we in a position with the state of the art at this time  
16 considering some of the success with infrared inspection, which  
17 is much more economical to determine the exact method in this  
18 spec at this time?

19 HALPERT: Well, I can say that 2.5 now, is for the  
20 substrate only. What we're trying to do is determine whether  
21 in processing the substrate has been cracked or broken or cut  
22 in any way. And this is a suggested means of doing it. And  
23 if you have others, certainly we would be interested in it.

24 GREEN: Well, my remark is based on the recent  
25 experience with solar cells where we determined cracks in

1 soldering and so forth by the infrared method demonstrated  
2 pretty beautifully and now under investigation. And I can  
3 see the substrate material we're talking about being cracked  
4 and so forth in shipment from past experience -- undue jars  
5 and what not can sometimes cause these cracks. It may be  
6 that infrared would be a more economical way to show it up.  
7 That's my only point.

8 HALPERT: Thank you. Any other comments with regard  
9 to this particular section, down to 2.4.2.8?

10 Okay, we go on to 2.4.3, Sample Plate Electrical  
11 Formation Test.

12 Now, just in opening, I would say the same thing as  
13 I did before -- these are samples of the plates that we are  
14 talking about, that are samples from the given whole batch.  
15 These are not 100 percent of the plates in the batch -- only  
16 a sampling, which was spelled out in that MILSPEC 105-D.

17 All right, with regard to that, 2.4.3. Comment:

18 "Although we do not object to conducting the test  
19 outlined in this paragraph, we do question the value of  
20 running both plate formation pack tests and individual  
21 formation tests, since it would seem that the information  
22 from the former can be deduced from the information from  
23 the latter. Note also that we consider these tests as  
24 being extensive and expensive especially when performing  
25 a spectrographic analysis of twenty percent of both positive

1 and negative plates of each sample group."

2 I have a comment from Mr. Herzlich of Marathon, and  
3 he wants to talk for about five minutes on this subject,

4 "To assure optimal reliability and overcharge  
5 capability, 100 percent testing of plates is desirable.  
6 In this way, individual plate capacities can be matched.  
7 The result is a uniformly high negative to positive  
8 capacity ratio."

9 Did you want to say any more than that?

10 HERZLICH: From your statement, I understand the  
11 scope is slightly different -- that this is simply an accept-  
12 ance at that point, and although I can't find it, you seem to  
13 be saying that later in the spec each of the plates will be  
14 capacity-tested?

15 HALPERT: No.

16 HERZLICH: Then I'll reserve my comments to that  
17 portion of the spec where we talk about the capacity of plates,  
18 which I believe is later on.

19 HALPERT: Okay. We're talking -- the visual inspec-  
20 tion, now, on this sampling, is only for the plate acceptance  
21 test. Later on, when we've put the plates -- use them in the  
22 cell, put them in the formation test, it's done on a batch  
23 basis, not on a plate basis.

24 HERZLICH: At that time I'll make my comments.

25 HALPERT: Okay, thank you. I have one more comment

1 on 2.4.3 -- No, I guess that's a little later on.

2 Okay, let's ask for comments there, on 2.4.3, A. B.  
3 C.

4 (No response.)

5 Okay, 2.4.3.1, I have no comments on .1 or .2.

6 Would anybody like to discuss .1 or suggest some changes to  
7 .1?

8 (No response.)

9 Does anyone want to say something good about it?  
10 Show their approval in some way? Some of these, as I mentioned  
11 before, we're looking for support in this matter, and not  
12 only are we trying not to make it tough on you; we're trying  
13 to be helpful. And we would like your help in this matter.  
14 We'd like some support on some of these items that we're  
15 talking about.

16 VOICE: That will, I think, be covered later, but  
17 I would like you to consider that an acceptance of the lot  
18 at this point may really not be necessary since you will be  
19 doing batch determination later on. So I would suggest that  
20 one of the considerations is that this test be omitted at  
21 this time, and be reserved for the evaluation of the batch.

22 BELOVE: Belove, Sonotone. Actually, this should  
23 be left to the discretion of the manufacturer. If he chooses  
24 to -- and he should -- sample before he does 100 percent test-  
25 ing. It obviously makes sense. But I don't think this has to

1 be included in the spec, if you're going to do 100 percent  
2 testing later on.

3 HALPERT: I want to clear up that point. We're not  
4 doing 100 percent testing later on. We're doing 100 percent  
5 visual inspection later on. We are only doing testing by  
6 batch later on. There's no individual samples taken after  
7 this particular section.

8 BELOVE: This is our main point. We recommend 100  
9 percent testing instead of batch testing, which we consider  
10 merely the use of averages. We think that averaging is not  
11 the way to attain the high reliability that is required in  
12 this product.

13 HALPERT: Yes, sir.

14 FORD: Jerry, to really clarify that point, I hope  
15 once and for all, this is a pre-production sampling that's  
16 being done, to accept the production run as flight-quality  
17 material.

18 In the inspection in production, that we'll get into  
19 later on, there is only a physical inspection, so to speak.  
20 There is no electrical testing on a 100 percent basis.

21 HERZLICH: Herzlich, Marathon Batteries. At that  
22 time we will make some recommendations about the 100 percent  
23 testing.

24 GASTON: Gaston, Grumman. Here it says counter  
25 electrodes for larger capacity, maybe an inert electrode can

1 be considered, provided the electrolyte bath is large enough  
2 so that you don't change the concentration.

3 HALPERT: Which paragraph are you referring to now?

4 GASTON: 2.4.3.1.1, this counter electrodes of  
5 larger capacity.

6 HALPERT: Okay. Are there any comments at all with  
7 regard to .1.2 or .1.3?

8 SULKES: Sulkes, U. S. Army Electronics Command.  
9 The fact that you call out a special KOH formation, which  
10 doesn't really mean anything -- suppose someone just wants to  
11 use plain KOH, or doesn't want to soak them for that period  
12 of time? This would seem, you might say, to be a useless  
13 paragraph, in that it sets no requirement at all.

14 HALPERT: I think we spelled out somewhere about  
15 the KOH. I don't know where it's spelled out. Does anybody  
16 recognize where that was defined -- that specification?

17 BILLERBECK: Next paragraph.

18 HALPERT: Oh, is it? Yes. The special KOH solution  
19 is the next one.

20 BILLERBECK: It refers to 5.2.

21 HALPERT: Any other comments now with regard to .3  
22 or .4?

23 REED: Reed, Battelle. This special KOH formation  
24 electrolyte, you've soaked the separator in it for 48 hours.  
25 It seems to me that this is a good source of impurities, if



1 there are leachable organics in the separator, which you might  
2 want to eliminate. In fact, I think I might suggest that the  
3 formation electrolyte, both here and later on, be the same  
4 electrolyte in which the cells -- which will be placed in the  
5 cells. In other words, if you're going to put in an additive,  
6 you ought to also have the additive in the formation electro-  
7 lyte.

8 HALPERT: I have a comment here that I missed, on  
9 2.4.3. Comment:

10 "Although we do not object to conducting the test  
11 outlined in this paragraph, we do question the value of  
12 running both plate formation pack tests and individual  
13 formation tests, since it would seem that the information  
14 from the former can be deduced from the information from  
15 the latter."

16 I read that.

17 All right. 2.4.3.1.4., a question about --

18 "Soluble organics in formation electrolyte can  
19 contaminate electrodes." And that was Mike Reed.

20 Okay, fine. Okay, any other questions in regard to  
21 2.4.3, down to .9? Any comments on .6? What we're essentially  
22 doing here is running a formation on a plaque and a plate  
23 basis, to get the variation within a group of plates, a  
24 sampling of a group of plates from a batch, to determine what  
25 the average is and how wide the variation is, and what we can

1 expect in a formation pack that might contain up to 20 or 21  
2 or 23 plates.

3 GASTON: General comment. I think it might be  
4 helpful to specify a temperature which the formation shall be  
5 conducted, and possibly a current density, so that eventually  
6 when more information is available, you will be able to  
7 collate all the information, and you might be able to come  
8 up with some tolerances, and specify what the limits should be.

9 HALPERT: Okay. I think the rate is spelled out  
10 in the paragraph before, that the rate for each sample plate  
11 shall be based on the current density used for a cell pack.  
12 So that we're essentially forming a plate.

13 Any other comments now down to .9? Okay, we go on  
14 to 2.4.3.2. Here we're running a second group of plates, in  
15 order to determine electrode capacities -- plate capacities.  
16 Any questions regarding that? .1 or .2? Yes, sir?

17 BELOVE: Belove, Sonotone. The same comment would  
18 appear to apply here -- that if, as we propose, 100 percent  
19 testing is instituted, then this is not required -- this  
20 testing, sample plate formation packs. In other words, again,  
21 we recommend 100 percent testing of the plates, rather than  
22 sample testing or 100 percent testing of the formation, or of  
23 the pack.

24 HALPERT: I might make one statement here about that.  
25 A lot of this was written based on prismatic cells, which of

1 course, you now have 21 to 23 plates in an order of 100 cells,  
2 you can see we're talking about quite a number of plates --  
3 thousands of plates. And it's difficult, and I think the  
4 manufacturers agree it's difficult to do it on a large lot  
5 like that, where you have many fewer plates, and you could do  
6 it in a cylindrical.

7 BELOVE: Jerry, I think you must agree to this:  
8 That if you're asking for a five or ten-year life and we don't  
9 really know what constitutes the makeup of the cell or the  
10 battery that will give us that, and you're trying to go --  
11 what we're trying to do here is go mid-point. And what we're  
12 saying is you've got to go all the way. It's not sufficient  
13 to take half measures. Either take all measures or do as you  
14 have in the past -- sample the cells and try to test quality  
15 into them.

16 BILLERBECK: Billerbeck, COMSAT. I would like to  
17 make a general comment, since we're getting into a bit of  
18 philosophy here at the moment. And I think the purpose of  
19 this particular section -- maybe we could just enlarge on that  
20 for a moment -- was to attempt to determine whether the plates  
21 had the basic electrochemical properties that you need to  
22 build the cells, and that this be determined before production  
23 runs off a thousand plates and then comes back and tells  
24 engineering, "Well, gee. You know these are 10 percent low in  
25 capacity, but come on. We'll have to buy them off. We're

1 committed now."

2 So the purpose is to determine before you get all  
3 the way down to the production process, that, gee, these plates  
4 really are capable of producing the capacity needed.

5 HALPERT: Okay, any other comments with regard to  
6 that?

7 NIETZEL: I think you forgot one of my comments,  
8 Jerry. And that was this: This procedure is only necessary,  
9 and I'm talking now about 2.4.3, all the way to 2.4.3.3.1 --  
10 and that is that this procedure is only necessary when the  
11 plate manufacturing process does not normally produce data  
12 indicating that electrochemical capacities of both the  
13 negative and positive plates.

14 Also, the use of special separators and pre-soaking  
15 is restrictive in that other processes used today do not  
16 require these operations. Similarly, the use of pack forma-  
17 tion is restrictive and is not required in all manufacturing  
18 procedures.

19 And I wondered if we are talking about 100 percent  
20 inspection, or are we talking about 100 percent sorting?

21 GROSS: One of the initial steps here is to perform  
22 the formation according to the manufacturer's procedure.  
23 Manufacturers can adopt formation procedures such that if at  
24 the end of the formation program the capacity of the cells is  
25 failing, or other bad features observed, they can add

1 additional steps to -- additional formation steps -- which  
2 will try to salvage that batch, and increase -- bring the  
3 plates up to the requirements.

4 This should be excluded.

5 HALPERT: Any other comments with regard to this?  
6 Okay, we'll go on to 2.4.3.3. and .3.1 in which we're holding  
7 some of these sample plates up for physical and chemical  
8 analyses -- in 2.4.4 -- nothing unusual there.

9 All right. I have a comment with regard to 2.4.3  
10 and 2.4.4.

11 "We believe, in view of the cost of these tests and  
12 analyses, that it be verified that all are actually  
13 required in the production of space cells. We recommend  
14 that all of these requirements be imposed on the  
15 manufacture of one lot in an effort to determine their  
16 relative importance on the characteristics of the final  
17 cell."

18 Any comments with regard to 2.4.4. or 2.4.4.1?

19 Okay, we go on to 2.4.4.2. Comment:

20 "The spectrographic determination of sulphur is not  
21 normally performed. Analysis for sulphur is more easily  
22 performed using an induction furnace absorption train and  
23 apparatus."

24 In all of these, now, we're making tests, physical  
25 and chemical measurements on these tests -- on these plates --

1 from the sample, and if you have some suggestions other than  
2 what are listed here, we certainly would appreciate hearing  
3 from you, on tests that you may do normally in-house that  
4 would be helpful in accepting or rejecting a plate lot, or in  
5 at least characterizing the materials.

6 All right, going on to 2.4.4.3 -- any comments?

7 2.4.4.4, Comment:

8 "The determination of negative plate porosity and  
9 pore size cannot be readily performed using mercury  
10 porosimeter techniques, due to amalgamation of cadmium  
11 metal which is present after formation. Other penetrat-  
12 ing liquids would have to be used."

13 Anybody want to make a comment? Dr. Parry?

14 PARRY: I think there's a more fundamental objection  
15 to mercury porosimetry for determination of pore size distri-  
16 bution. All you really see is a breakthrough pressure, and  
17 it gives you nothing of the actual distribution that you have  
18 there. Metallographic techniques are far better in this  
19 respect.

20 HALPERT: You're talking about the plates now, as  
21 well as the plaques?

22 PARRY: Plates and plaques, yes.

23 HALPERT: Any other comments with regard to 2.4.4.3  
24 and 2.4.4.4?

25 We go on to .5. Any comments with regard to .5?

1 (No response.)

2 HALPERT. .6? .6.1?

3 (No response.)

4 HALPERT: 2.4.4.6.2. I have a comment.

5 "In addition, the amount of cadmium metal must be  
6 determined for a complete analysis of the plates."

7 Any comments on .3 or .4?

8 PARRY: Parry, TYCO Labs. I think, going back to  
9 .6, the leaching out of active materials -- I don't know at  
10 the moment of an effective way of doing this for the positive  
11 plate. Almost all the methods that are looked at involve  
12 some dissolution of the substrate as well as of the porous  
13 nickel or the screen.

14 I think this should be taken into account in writing  
15 the specification.

16 HALPERT: Any other comments regarding this entire  
17 analysis of the plates? I assume you are all doing this and  
18 getting good results.

19 All right. We're at the end of section 2, and I  
20 think, according to our schedule we had planned to only go  
21 to section 2 by 12:15. The cafeteria is available to us at  
22 12:15 -- that's the cafeteria across the way, Building 1.  
23 So we have about 40 minutes or so to talk about specifications  
24 in general philosophy. And I would just like to hear some  
25 general comments about the spec, how you think it should be

1 put together, is it acceptable to you, would you accept the  
2 first two sections if you were given it tomorrow and told to  
3 build cells based on this spec?

4 Any general comments about it?

5 THIERFELDER. Thierfelder, G.E. Space Systems. Well,  
6 one general comment that I have is that I think the spec  
7 should be broken down into a cell spec, and an individual  
8 specification should be prepared for plates, separators,  
9 electrolytes -- you could probably limit it to those three --  
10 but to put everything into one specification, you're covering  
11 one assembly and then several sub-assemblies. And I think it  
12 would be preferable to break it down into the components of  
13 the cell, specifications for those items. This is the way  
14 it's been done in many other battery specifications.

15 HALPERT: Would that mean that one specification  
16 is referenced --

17 THIERFELDER: That's right. In the cell spec we  
18 would call out the plates will meet specification so-and-so  
19 for plates, and the separators used in this cell shall meet  
20 the requirements of the specification (b), and the electrolyte  
21 used in this cell shall meet the specification (c).

22 CARR: Carr, Eagle-Picher. My feelings on this  
23 are that I think that the battery specification should be  
24 complete as possible in one document. I think, however, that  
25 if there are areas of work that are not done by the battery



1 vendor, that they should be covered by a separate spec -- such  
2 as separators.

3 HALPERT: Any other comments regarding this?

4 MAURER: I have one additional comment, Jerry, over  
5 here. It was mentioned earlier that we have assumed a slurry  
6 type of plaque fabrication. There's also the possibility on  
7 the negative electrode of no sinter at all. This should be  
8 considered.

9 In the formation we have considered only electro-  
10 chemical formation, and there are chemical formation proced-  
11 ures which should also be considered -- or at least not ruled  
12 out.

13 HALPERT: Okay, any other comments with regard to  
14 that?

15 MC CALLUM: Mc Callum, of Battelle. I was inter-  
16 ested that almost any paragraph, you can determine a surface  
17 area pore size distribution or record the weight and thickness  
18 and there is no indication about what the numbers ought to be.  
19 And I wonder, where are those coming from? Are you going to  
20 furnish those later, who who is supposed to do that?

21 HALPERT: Well, this is supposed to be from a matter  
22 of experience. We hope, by putting in the spec the fact that  
23 these numbers should be measured, that although we can't hold  
24 you to any, we wouldn't expect to be able to hold you to any  
25 particular numbers or any particular limits -- that is, hold

1 the manufacturers to any particular numbers or limits -- that  
2 ultimately we would have enough data compiled to know that a  
3 batch of cells should have these particular limits, and then  
4 be able to specify those later on.

5 Now this is certainly not a short time in coming.  
6 We don't expect this tomorrow or the next day. But there are  
7 a number of people working on evaluating materials in govern-  
8 ment agencies and under contract, and we hope that it won't  
9 be too long before we have some numbers that we can start  
10 applying to these various places in the spec.

11 GROSS: Gross, Boeing. A test should be added to  
12 determine the tendency of the active material to flake off  
13 the sinter. This probably can be done by an overcharge test.

14 LANDSMAN: Landsman, Lincoln Lab. If I'm not  
15 mistaken, we're in for some philosophy?

16 HALPERT: Yes. Speak your piece.

17 LANDSMAN: I think this specification is more than  
18 just a manufacturing specification for the manufacturers to do  
19 such and such. There was a comment about measuring effluent  
20 gases on drying, and that would not be used for process control.  
21 But I think this kind of information is the kind of information  
22 we want, because five years from now or ten years from now, it  
23 will possibly turn out that certain cells do last longer than  
24 other cells, and we would want to look back and see what is  
25 the difference, or where there any differences in the manufactur

1 And that's the thing we can't do now, because we do find some  
2 cells do last longer than others, and we don't know why.

3 HALPERT: I think that's the big problem -- we have  
4 nothing to refer back to. Changes are made from time to time  
5 to upgrade the product by manufacturers, and at that same  
6 time, really none of us know what the long-term effect is  
7 going to be. And I think that this spec really just gives us  
8 some numbers to hang our hats on a little bit later downstream,  
9 to see where we will be.

10 FORD: Jerry, I would like to make a comment to  
11 reemphasize what Mr. Landsman has said. I have had experience  
12 in talking with other people in other areas of aerospace  
13 products, that every test you conduct on a product isn't  
14 necessarily a "go, no-go" test. And this is especially true  
15 even at spacecraft level. You don't test the black box just  
16 to find out if you can go or no-go; you test to find out what  
17 characteristics it has.

18 And the purpose -- this is the purpose and the  
19 intent of a lot of these tests, to clarify the point that  
20 certainly in a lot of these areas there is no limit specified,  
21 for the simple fact that I don't think anyone here knows what  
22 the limits can be.

23 But after you have tested batteries for five years  
24 and you say, "They look great," and turn around and want to  
25 build the same battery again and find out you don't really

1 know what went into that battery, you've got a difficult  
2 problem, because you'll build another battery and you'll want  
3 to say it's going to last five years, because I did it like  
4 this before. But what was before? We don't know that today.  
5 And until we take a more subtle approach to this type of spec-  
6 ification, we're not going to have the information necessary  
7 to reproduce high-quality products day after day, year after  
8 year, and decade after decade.

9 CORBETT: Corbett from Lockheed. I guess what Floyd  
10 just said kind of touches on something I was going to say.  
11 If I interpret things correctly, or if I interpret the intent  
12 of this meeting correctly, it is to kind of rigidize the  
13 processes that the vendors have now -- that is, we assume  
14 that someone has on the average a pretty decent nickel cell,  
15 and we're trying to specify the process enough so that it will  
16 continue to be the same.

17 But on the other hand, we have been buying batteries  
18 and cells in the past completely on a performance spec, and  
19 this performance spec has been more electrically-oriented than  
20 anything else. And very often it's been highly specific to  
21 the actual application of the spacecraft, and so forth.

22 But I would think, if not at this point, at least  
23 at some point, when we later get a better cell or a more re-  
24 producible cell, that we could get back to some sort of a  
25 performance spec. And I think I'd like to see some attention

1 paid to the consideration of making tests on cells to deter-  
2 mine if indeed they are what you expect a nicad cell to be --  
3 things like overcharge tests, end of charge voltage tests,  
4 and things like this.

5 I think this is the more desirable approach, but  
6 the only problem now is that we don't know what a nicad cell  
7 is supposed to act like. And I think that's what is basically  
8 the problem.

9 BELOVE: Belove, Sonotone. There's one point. I  
10 don't know whether anybody has mentioned this in the past,  
11 we have a specification here and I think on the whole, I  
12 appreciate what is trying to be done and as a battery manu-  
13 facturer I know why it's being done.

14 But I'm curious about something here. Many years  
15 ago when I first started working, I thought I knew all about  
16 electroplating, and so I specified to a plater exactly how to  
17 plate silver onto -- I think it was copper at the time -- and  
18 he followed my specs. And it didn't work out right. And when  
19 I brought it back to him and I said, "Well, you can redo this."  
20 He said, "I'm sorry, I followed your directions. It's yours."

21 And now I'm wondering, as a manufacturer, if I  
22 follow every step of these directions, and I make the product  
23 and it doesn't work out, whose product is it?

24 (Laughter.)

25 BILLERBECK: Well, I think there are several -- I

1 believe Tom mentioned today, and I think I mentioned it too --  
2 that there has been some realization by the Committee that we  
3 really don't want to rigidize the manufacturer's process.  
4 What we, I think, really are striving for here is to get  
5 testing during the manufacturing process that allows the  
6 manufacturer himself to know his process better and be able  
7 to reproduce it in the future.

8 And I think that's an important input here, that  
9 we -- and I think it has been brought out as we go along --  
10 that we feel that there are some areas that need to be  
11 broadened to include more than one process.

12 We're looking for suggestions as we go along here,  
13 from each of you.

14 COHN: Cohn, NASA Headquarters. I didn't think it  
15 would be necessary, but maybe I'd better say so -- that we're  
16 not stopping R&D on nicads, because we think we have a final  
17 process. Originally I did not feel very happy about going  
18 into this kind of spec writing for just that reason, which  
19 apparently is bothering some people now.

20 But the point is, apparently we could not get the  
21 product we wanted without rigidizing the -- not necessarily  
22 the manufacturing procedures, but at least the characteriza-  
23 tion procedures. This does not mean that from time to time  
24 these specs can't be rewritten, as we learn more and as we get  
25 better products.

1           HALPERT: I think, in relation to this, I think  
2 what we're looking for is traceability as well, and recording  
3 of the data, so that we can use it for some basis later on.  
4 If we don't have this information, and we don't ask for it,  
5 we'll be in the same state as we are today, and as we were a  
6 number of years ago.

7           LANDSMAN: Landsman, MIT. I think an example of  
8 this -- I think it was mentioned last year at the meeting  
9 here -- had something to do with the amp hours of cells  
10 increasing with cells being made the same way over the years  
11 and people getting more ampere hours out of them. And  
12 somebody mentioned that they didn't change their process.

13           HENNIGAN: I think in this case, one of the problems  
14 we had last year --we have a gut feel that these plates were  
15 changing over the years. Somebody had been checking them,  
16 maybe we would have noticed a change and at least would have  
17 questioned it.

18           GROSS: The specification asks that a lot of data  
19 be taken to determine -- for traceability and for records.  
20 In addition to the data, it would be very useful to have -- to  
21 preserve samples of materials that are used from batches, so  
22 that specific tests at a future date can be conducted on the  
23 materials -- plates, plaques, separators, et cetera -- that  
24 went into the manufacture of the cells.

25           HALPERT: How about some comments from some of the

1 other manufacturers here with regard to the spec? I think  
2 the users and the other government people would like to hear  
3 some comments, in general, from them. Is anybody interested  
4 in saying anything?

5 GASTON: Gaston, Grumman. I'm not a battery manu-  
6 facturer, but I have a comment from what we have mentioned  
7 before.

8 We go and collect a lot of information, and I'm  
9 concerned about the data feedback. Each user will have  
10 various types of information based on his background, and of  
11 course various government agencies will have some information,  
12 depending on where the contract originated.

13 But is it possible to set up a central source where  
14 the information will be sent to, and eventually you might be  
15 able to have a much better picture, an overall picture, from  
16 everybody's experience? And then you can tighten the specifi-  
17 cation accordingly. I think it might be helpful if the  
18 information will be submitted to one specific source, where  
19 it can be analyzed and evaluated.

20 BILLERBECK: I guess we're looking to NASA Goddard  
21 as the center at the present time, or NASA in general.

22 STEMMLE: Stemmler, Goddard Space Flight Center. I  
23 have a small comment. It seems to me that the title of this  
24 spec is misleading. It's not necessarily specifying the  
25 product cell that is delivered, but the mass of information



1 that you know about it.

2 But I think it's a good spec and worthwhile. It's  
3 a positive comment. But I think what it really amounts to is  
4 that the whole battery industry in this country is undertaking  
5 a vast research program in which all these parameters that  
6 we are specifying to the n'th degree are going to be studied,  
7 so that in the future, when a failure occurs, it just fits  
8 into part of the research program. You go back and perhaps  
9 trace it to a variation in some of the determined parameters.

10 FORD: Ford, NASA Goddard. This spec in the aero-  
11 space industry is not setting a precedent by any means. For  
12 example, I was cited the other day, in talking with project  
13 people about this type of spec, that in other areas -- and  
14 they gave me the example of a valve used in a spacecraft, a  
15 very critical valve -- it's a valve that you can go out in any  
16 store today and buy for \$3.65. It cost \$1700 -- to use in  
17 a spacecraft, the valve cost over \$1700. And in itemizing the  
18 cost, comparing what the difference was between aerospace use  
19 and a commercial use, is the man-hours and materials that went  
20 into it. It was basically the same materials, but the tests  
21 that went into testing the basic material that went in the  
22 valve. And this valve is manufactured by one of the leading  
23 aerospace companies, incidentally.

24 So we're not setting a precedent in this spec. I  
25 think we may be setting a precedent, somewhat, in the battery

1 industry, in looking at this concept.

2 BENE: I certainly hope that the ratio of the  
3 commercial valve cost to NASA's cost isn't reflected in  
4 batteries.

5 (Laughter.)

6 HALPERT: I think we're trying to look at it in  
7 terms of -- we expect higher costs; certainly the manufacturers  
8 have mentioned this, everything being cost impact on every-  
9 thing we want to do -- I think we're certainly willing to pay  
10 this higher price for a more reliable piece of equipment.  
11 And I think if we have the numbers and if we can control the  
12 tolerances and we can have a better feel that we're going to  
13 get reproducible materials, throughout a 22-cell pack, which  
14 is what we're looking for, then I think we can -- it will be  
15 well worth it to us. We won't have to go through some of  
16 the problems that we're going through now to qualify and  
17 requalify and choose materials by hand, without real good  
18 knowledge.

19 STEMMLE: It might be looked upon as a cheap way of  
20 doing research, really. We're going to have cells built for  
21 hardware, spacecraft, aircraft projects. And these are going  
22 to be useful cells. But at the same time they can be  
23 considered research things. And that can be compared with  
24 a research program of the size where you'd buy this many  
25 number of cells. I don't know in the next ten years how many

1 cells are going to be bought, but if they were all bought for  
2 research purposes, with no other purpose in mind, it would  
3 be rather prohibitively expensive.

4 So it looks like a -- rather than making expensive  
5 cells, you're buying cheap research.

6 YERKES: Yerkes, Heliotek. I presume, since you are  
7 indicating you want to buy more paper, that you would just as  
8 soon get less pounds of batteries to sort of balance things  
9 out. And I know, from having seen a number of the labs that  
10 the users have set up, that the time and effort spent and  
11 wasted in combing through the product that's submitted, is  
12 certainly not cheap. And I would presume this is a reaction  
13 by the users of cells, and therefore it's something that  
14 obviously is going to have to be responded to in one form or  
15 another, and should result in less cells having to be  
16 purchased to do a given job in a given schedule. And the  
17 schedule, and the time lost in the schedules, to me seem to  
18 be something that are also very important in dollars that  
19 aren't counted in the hardware budget. You have lots of  
20 people at these companies who spend a lot of time trying to --  
21 as somebody said earlier -- improve their cells by testing  
22 the hell out of them.

23 So I think this is probably a natural thing, and --  
24 we manufacture solar cells. We go through this same sort of  
25 thing. And I think we're in the same situation. We start

1 something like 20,000 solar cells a week right now, and some  
2 small percentage of them make it on to TRW or Hughes Space-  
3 craft or some other -- Grumman spacecraft -- or whatever it  
4 might be.

5 And this same type of logic is applied here and in  
6 many other areas, and I think it's probably just coming to the  
7 battery people.

8 HALPERT: What we hope to avoid, I might add here,  
9 is actually not exactly testing hell out of it, or analyzing  
10 it after it's made, but trying to have some control in the  
11 beginning so you don't have to test the hell out of it later  
12 on to find out what you've got. Hopefully, you'll have some  
13 prediction of what you have, by knowing what you put into  
14 it.

15 CARR: Carr, Eagle-Picher. First, just our reaction  
16 to the spec, as Eagle-Picher, and that is that we certainly  
17 agree with the intent of the spec.

18 Second of all, in response to the gentleman behind  
19 me, these tests are going to take a much longer time to build  
20 cells for your spacecraft, and I wish that the prime contract-  
21 ors and the NASA contractors would take this into account.

22 GASTON: Gaston, Grumman. So far, we've only been  
23 talking about increase in costs for the application or the  
24 installation of this new specification. There might be some  
25 cost savings, too. I don't say the savings are going to be

1 very considerable.

2 In the past we at Grumman had to do a very extensive  
3 cell selection for a specific flight battery. I have a little  
4 chart here which I had prepared and which certainly indicates  
5 with a partial installation of this new specification, you  
6 have much closer characteristics as far as capacities are  
7 concerned and as far as voltage spreads and overcharge are  
8 concerned.

9 If anybody cares, I'd like to show it on the wall.

10 I have three different batteries here. This  
11 battery was produced in September 1968, this one was produced  
12 in October 1968, this one was produced in October, 1969,  
13 just presently. And I compared the early cycle life capacity  
14 of cells made prior to selection. And these are 20 amp hours  
15 cells. And we found the early capacity spread from about  
16 23.6 to 27.2 and 24.2 to 28.2, and now from 25.6 to .7.

17 Let me add, the last battery was a partial require-  
18 ment or -- excuse me -- partial installation of making a  
19 requirement of the new aerospace specification. We couldn't  
20 install all of the requirements, because some were not  
21 practical because of schedule involvements.

22 And the overcharge voltage -- we overcharged these  
23 cells at three different temperatures. We charged at 40, 75  
24 and 90. These are currents -- 1 amp, 1.6 amps and 2.3 amps.  
25 Again, you see the voltage difference, or the spread, has now

1 narrowed down considerably.

2 So I believe with the closer controls of the details  
3 you can expect a closer control of characteristics, and  
4 eventually it will lead to a more reliable battery.

5 HALPERT: Any comments in regard to that?

6 THIERFELDER: Thierfelder, G.E. This is about  
7 something different -- I assume nobody had a question on that.

8 It has been mentioned that these cells we're talk-  
9 ing about are high reliability for five years and up.  
10 Currently all the RFP's that I've seen recently for batteries  
11 required two years and less.

12 Is it expected we'll have two grades of cells' or  
13 batteries, or is it expected on all the spacecraft that are  
14 two years and less, we'll use the same high quality reliabil-  
15 ity batteries as we're talking about here?

16 HALPERT: I guess that's up to the guy buying them.  
17 I would assume, from a personal way of thinking, I assume  
18 that once we have imposed the spec and once it is being used,  
19 a lot of these tests are going to be made a normal process,  
20 a lot of people are going to find that these tests are very  
21 good indications of what they're getting out of their own  
22 product. And they'll be using them anyway.

23 And I think you'll get a standard upgrading of all  
24 the products, including the commercial line, of all these  
25 materials.

1           THIERFELDER: Well, the question that comes up is  
2 that, will we have to pay the cost of the five-year cell when  
3 we only need a two-year cell?

4           BILLERBECK: You could use the rejects, you know,  
5 for the --

6           (Laughter.)

7           FORD: Jerry, I'd like to make a comment along those  
8 lines.

9           First of all, I don't believe there's any such  
10 thing as two qualities for space use. There's only the best.

11          Second of all, most of your life requirements are  
12 put in by project people. If you have a two-year life  
13 requirement, that may even have been defined as far as  
14 Headquarters, to meet this mission success requirement.

15          However, nobody is going to complain if you come in  
16 and say your battery is going to last five years. I can  
17 assure you of that. In order to get these long-life require-  
18 ments, we have to look at these higher controls.

19          The third point I'd like to make on this subject  
20 is that there is a definite trend in longer-lived spacecraft,  
21 particularly in the manned space station, where we're concerned  
22 with having to replace batteries on a shuttle-type operation.

23          So I think the day when we're talking about six-month  
24 batteries, one-year batteries -- and even to an extent, a  
25 two-year battery -- are pretty far behind us, and we're now

1 talking about five to ten years life. Because the spacecraft  
2 are getting bigger, they're getting more expensive, as we  
3 all know, being aerospace contractors.

4 So you have to look at this in the light of what  
5 the anticipated need is in the next decade. And it certainly  
6 is two years and beyond.

7 STEINHAUER: Jerry, I'd like to comment. First,  
8 with regard to the Eagle-Picher comment on lead time, as  
9 Floyd points out, we are getting to longer and longer lifetime  
10 satellites. Although I have seen a plan proposed, if Apollo  
11 lands near Surveyor 3 that they might plug in a battery, we  
12 don't ordinarily count on that. And we're committed, once  
13 we put these batteries on the spacecraft. And perhaps a  
14 little longer lead time is going to have to be tolerated.

15 SULKES: Sulkes, Electronics Command. One question  
16 with regard to the spec, this doesn't appear to prohibit  
17 pre-qualification. In other words, a small order is being  
18 bought, but actually a large lot of plaque material could be  
19 pre-production qualified and kept available for future small  
20 orders; is this correct?

21 FORD: Yes, sir.

22 SULKES: So actually, some of the lead time could  
23 be taken up in that manner, by having qualified plaque material  
24 on hand.

25 CARR: Carr of Eagle-Picher. The spec says there's



1 a six-month life on parts. So this is, right now, not  
2 practical. I think, however, one part of any work to be done  
3 in the future would be to consider how long is a plate good  
4 for, and what happens to it as a factor of storage, so that  
5 you can't use it.

6 We have definite feelings of our own about this.

7 In response to Bob Steinhauer's comment, all I  
8 really mean is that the Committee, in assessing how much  
9 testing should be done, I think that we should keep in mind  
10 the length of time that we're adding to producing batteries  
11 or cells.

12 GROSS: Gross, Boeing. In the course of the many  
13 inspections and tests, it will be found that some tests are  
14 really not adding very much to the quality. And the specifi-  
15 cation should be flexible enough so that expensive tests can  
16 be either deleted or shortened so that you could test them  
17 less frequently.

18 HALPERT: I think we're going to find that in some  
19 of these tests that they will be unnecessary. Once we're able  
20 to control and get some traceability on the product, when it  
21 gets downstream, I think we'll -- a lot of these tests will  
22 not be necessary. There will be one or two which we'll be  
23 able to spell out, where the problems really lie. And I don't  
24 think it's necessary to do all those.

25 What we're really looking for here are the optimum

1 methods to look at these materials -- in this particular  
2 section, anyway -- to look at these materials in terms of  
3 what has happened back downstream, and how can we best assess  
4 what's happened. After that, other than just specifying the  
5 initial materials going into the thing, and having some normal  
6 controls that one would expect, the amount of testing I think  
7 will go down significantly, at least at some future time, when  
8 we have all the numbers.

9 MC CALLUM: Mc Callum of Battelle. Because we've  
10 just concluded a job to recommend accelerated life tests for  
11 NASA, I feel compelled to comment on this problem of semantics,  
12 and words we bandy around.

13 There are quite a few people talking about quality  
14 and reliability and traceability, and several people have  
15 commented it's clear to them what the intent of this specifi-  
16 cation is; and this is one of the things that confuses me --  
17 what the intent of this spec is.

18 I gather it's an interim model specification for  
19 the data to be recorded in the manufacture of cells, and that  
20 there are not any specifications here on reliability, quality,  
21 or any other thing that we keep talking about. And somehow  
22 you've got to get that separated, or I know we've got a real  
23 problem.

24 HALPERT: Well, in answer to that I would say that  
25 what we require here is a specification at least of the number

1 of samples that should be taken and the tests that should be  
2 made. Now what the numbers come out to be, and how we can  
3 reject them, is the thing that we're going to have to deter-  
4 mine downstream. And that would be the basis for reliability  
5 in terms of a specification.

6 We can't really say right now what we can accept  
7 and what we can't accept. We have nothing to go by. But at  
8 least we can specify that at least this measurement should  
9 be made, and that measurement should be made, and in those  
10 terms it's a specification.

11 Now that may not be --

12 VOICE: Can't we change the title, then, to,  
13 "Specification for Amendments to be Made?"

14 (Laughter.)

15 HALPERT: The Committee will take that up.

16 RICHARDSON: Richardson from Marshall. When we  
17 first heard of the spec, I got a couple copies from old Tom  
18 over there, and we got a couple programs at Marshall there  
19 where we're using nicads, and in the ATM we attempted to  
20 impose the spec on a couple of battery primes, but the costs  
21 came back tremendously high. And as soon as the program  
22 manager saw the cost he said that's it, we can't have it. We  
23 can't stand the cost, and possibly schedule problems.

24 Has anybody here actually ever come up with an  
25 individual cost breakdown on a paragraph by paragraph basis,

1 in the spec?

2 And you keep getting the wrong figures, you know,  
3 "X" number of dollars per cell, or on a contract basis it  
4 increased a million dollars, or something like this.

5 We're talking about cells that last a year or less  
6 for our programs -- for these ATM airlock modules.

7 And I don't know - - there is -- I guess most of  
8 the thing does call for generation of an extreme amount of  
9 data here which would be extremely good in evaluating, like  
10 you say, if you got downstream one year and you wound up with  
11 cell failures, you could go back, possibly, and pick up  
12 something in the data that you have which may lead you to  
13 the failure mode.

14 COHN: Cohn, NASA Headquarters. Would you care to  
15 comment on the ratio of price increase, roughly at least?  
16 10 to 1, 100 to 1, 1,000 to 1?

17 RICHARDSON: I think it was -- one was about 5 to 1,  
18 something like that.

19 VOICE: Five to one was too expensive?

20 RICHARDSON: Yes. On the other one, I don't have  
21 any idea.

22 COHN: Too bad. It's ridiculous, absolutely  
23 ridiculous.

24 RICHARDSON: Well I agree with you, but when our  
25 program management sees this amount -- we're running on kind

1 of an austere schedule and dollar-wise, and the program  
2 managers can't stand it. From a quality standpoint I think  
3 it's excellent. The spec is top drawer, let's do it.

4 BENE: A cost of five to one can kill any program.

5 VOICE: It's not ridiculous. What if he only needs  
6 a six-month battery? They do lots of things for 30 days.  
7 It's got to be a cost-effective criteria.

8 FLEISCHER: Will this gentleman from Marshall please  
9 state -- when you buy batteries, you buy how many, enough  
10 for one satellite? Or do you buy a certain number for testing  
11 and now what do you go through, and what does this cost you  
12 on your present procurement? Do you know these batteries  
13 are going to do what you want them for for one year?

14 It might be interesting to hear some of the details  
15 to set a background for why we need this spec, and why  
16 everybody is agreed that there has to be a specification; and  
17 a problem that comes in, as far as I can see, is what shall  
18 we put into it and how far do we have to go?

19 I think I've stated the two things that are behind  
20 writing this specification. In other words, when you buy  
21 your batteries now, how do you know you got what you specified?  
22 You want a battery that will perform for one year.

23 RICHARDSON: We have come up with what we call a  
24 minimum spec, or minimum quality spec, for the batteries, which  
encompasses like receiving inspections on critical items,

1 review of the vendor's in-process specs, and so on, and  
2 specifying certain acceptance testing of cells if we're just  
3 buying cells from a supplier, or having one of our primes  
4 buying batteries or cells.

5 And then we have a section based on the acceptance  
6 testing of battery assemblies in that case, when we're buying  
7 the final batteries.

8 Hopefully-we at Marshall are building the CERM  
9 package for the ATM -- hopefully, we will run sufficient  
10 tests in the qualification area. We have several -- we have  
11 prototype vehicles -- I'm not sure of all the ones we have  
12 there, we'll be doing sufficient environmental testing on  
13 the testing vehicle, hopefully, to get us a good idea of how  
14 these batteries will perform in those areas, and through the  
15 qualification, and hopefully the implementation of the  
16 minimum quality spec, which will give us a good battery to  
17 last us the year that we want.

18 FLEISCHER: Well, actually, from what you have said,  
19 you're on your way to a specification of this type.

20 RICHARDSON: Yes, we have a specification which  
21 encompasses some of the items that you have in here also.  
22 But I can't say right now, today -- look ahead a year and  
23 say, "Yeah, that was great," or it didn't buy us a thing.  
24 But our program management kind of put the - - he said, "What  
25 are the minimum requirements that you, quality, can stand

1 ' without the costs getting out of line?"

2 BILLERBECK: Billerbeck, COMSAT. I think a great  
3 deal of this depends too on whether the costs are in the  
4 original budget for the program. If you go by and try to  
5 retroactively introduce a factor of five increase in cost,  
6 that's a real problem; whereas if it's in the program from  
7 the start, then you have a little better situation.

8 RICHARDSON: That's true.

9 HALPERT: I think what we have to do is --

10 CORBETT: Corbett, from Lockheed. I have two  
11 comments. First of all, I think it's meaningless to talk  
12 about an "X"-year battery -- a five-year battery or a ten-  
13 year battery. And I think where this word comes from is  
14 because COMSAT or the Air Force or someone like that talks  
15 about a five or a seven or a ten-year spacecraft.

16 If you give me a battery that you guarantee to be  
17 a ten-year battery, I guarantee you I can make it last for  
18 only two years. Because everyone knows that the battery life  
19 depends upon the regimen that you put it through.

20 But I think what we're talking about here is a  
21 battery which can last for five years, and which will give  
22 reproducible results from month to month, and from year to  
23 year on lot to lot.

24 All this testing goes for naught if you can't be  
25 sure after you've sampled the 1,000 cells and taken them down

1 to Marshall to test them, that the next battery you buy is  
2 going to be a different animal.

3 The other comment was that -- on what Mr. Billerbeck  
4 said before -- concerning this business of the purpose of  
5 the spec. If you expect to get data on how to build a nicad  
6 cell, after implementation of this spec, or if the intent is  
7 indeed that the spec will generate some good data, I'd  
8 suggest that a more efficient way to go about that particular  
9 task is to sponsor work to determine what the battery should  
10 be, what are the optimum parameters. And then, perhaps, the  
11 spec is a more meaningful thing to implement at that point.

12 FORD: Jerry, I think, as a lot of people are aware,  
13 we are responding to that type of requirement. We have  
14 numbers in the spec at this time, in some cases. In some  
15 cases there are no numbers. And we realize that there is a  
16 lot of work -- one hell of a lot of work -- that has to be  
17 done to put parameters or limits on these numbers.

18 Therefore, no attempt has been made to do this at  
19 this time.

20 In regard to the gentleman from Marshall, I'd  
21 venture to say that had he showed the project management in  
22 the early stages the cost of testing his batteries, as  
23 compared to the cost of buying a high reliability part to  
24 start with, that the tradeoff would not have been too  
25 different.



1           And the third comment I would like to make, in  
2 regard to Mr. Gaston's statement, is about my estimate. My  
3 estimate is that about 50 to 60 percent of this spec has  
4 been included in the most recent OAO cell spec that he was  
5 explaining the data from. And you'll find out when you look  
6 at this, and really get down to the nitty gritty of the  
7 situation, it's not that hard to implement. It does cost  
8 more money. But in the long run, I think there may be a cost  
9 savings.

10           Consider the example, if I have to buy 150 cells  
11 to get 66 flight-quality cells, I feel that with the realiza-  
12 tion of a better quality control and implementing a spec,  
13 that may result from this, that the number of cells you have  
14 to buy initially will decrease, and most likely the rejects  
15 that the manufacturer had with his own facility is going to  
16 decrease.

17           HALPERT: Okay, if I may at this particular point --  
18 we're getting into our lunch hour now -- I do want to make  
19 one comment.

20           Among our very distinguished guests here, we have  
21 some very special ones from our neighbors to the north, from  
22 Canada. I'd like to recognize Dr. Tom King, Sir George  
23 Mackie, and Mr. Stott, from the Defense Research Establishment,  
24 Ottawa, who have come down here and are helping us on an  
25 international relations arrangement, to get a better spec so

1 that we all can work well together. We appreciate your  
2 coming down.

3 At this particular point then, being a little after  
4 12:15, we will adjourn for lunch. We will be returning at  
5 1:15.

6 (Whereupon, at 12:15 p.m., the meeting was recessed,  
7 to reconvene at 1:15 p.m.)

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AFTERNOON SESSION

(1:35 p.m.)

HALPERT: Gentlemen, can we take our seats, please?

I would like to start this afternoon's meeting off by first making an apology to Dr. Tom King. I introduced him as Dr. Tom Scott before, so I thought I was cementing international relations and here I was cracking them wide open. I do apologize, Tom.

Secondly, we are going to skip over the separator section this afternoon and plan to start that first thing tomorrow morning.

We have two gentlemen who are very much interested in being here for the separator part and they could not be here this afternoon. So we are going to skip by 3 and we are going to skip by 4 until 3:00 o'clock this afternoon and we are going to go directly to 5 at this moment which is really dealing with the basic material.

Okay, let's start off with Section 5 which deals with the water and the electrolyte, and we see here in 5.0 and 5.1 and 5.1.1 we talk about deionized water and how it is -- what resistance it should have. The resistivity of the water shall be no less than .5 megohms. To increase this level to 1.0 megohms requires removal of an additional .5 ppm. In light of other impurities present in the process, i.e., 10 ppm carbonate in the electrolyte, 1 ppm nitrate in electrolyte and

1 approximately 1000 ppm chloride ion in the separator, this  
2 level of purity in the process, water becomes by proportion  
3 insignificant.

4 I wonder if anybody had a comment about water in the  
5 conductivity of water.

6 Yes?

7 CARR: I think maybe instead of saying deionized  
8 water, leaving you kind of open, I think maybe we ought to be  
9 talking about again limits regarding maybe this can be  
10 determined by the committee from some of the work that has  
11 been done on impurity studies.

12 HALPFERT: Any other comments regarding this?

13 CORBETT: This is kind of a small comment, but I  
14 think there are probably better ways of measuring conductivity  
15 of water to determine its purity, and with a cell that from  
16 what I can see is the type that is normally used for highly  
17 conductive electrolytes, it is down in the conductivity range  
18 of potassium chloride, and with a standard bridge, when you  
19 get up around -- if the bridge is designed to measure solutions  
20 on the order of this conductivity, when you are measuring  
21 things that are in fact up around megohms the results are very  
22 poor. So you might want to have a special cell or perhaps an  
23 electrolysis method to determine the purity of the water.

24 HALPFERT: Is there another comment about that? Do  
25 you think the electrolysis method would be as accurate as using

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1 conductivity cell? I don't know.

2 CORBETT: I don't know, but I think it could be  
3 designed for that application.

4 FLEISCHER: I think that one of the things that  
5 has been missed in this is that you cannot measure the  
6 conductivity of certain organic compounds like sugars and  
7 related compounds that might be in the water, especially in  
8 the fall of the year when the water is coming off of old  
9 leaves and fallen leaves and dried leaves, so that you might  
10 be using water that is very impure with respect to ultimate  
11 formation of carbonate or of materials that can affect the  
12 electrodes.

13 HALPERT: Is your suggestion to --

14 FLEISCHER: We will have to add something to allow  
15 for residual matter in the water.

16 BENF: 5.1.6.

17 HALPERT: Any comments about .5 megohms with respect  
18 to 1 megohm? Does anybody have any strong feeling one way or  
19 the other that it is difficult to get .5 megohm, difficult to  
20 get 1 megohm?

21 (No response.)

22 HALPERT: Okay, 5.1.2 where we talk about the  
23 resistivity, 5.1.3. I think the intent of 5.1.3 was to have  
24 some standardized method or some standardized cell for  
25 measuring so you don't keep measuring with the same cell and

1 then find out downstream that that cell was actually reading  
2 incorrect and you find a way of standardizing it. And any  
3 other way, if there are any other methods, that certainly  
4 would be reasonable.

5 5.1.4.

6 PFED: Just a little point on 5.1.3. You have  
7 listed here the conductivity of 1410 plus or minus 20 micromhos,  
8 should be micromho centimeters at 25 C for 10th molar KCl.  
9 According to the handbook the conductivity of 10th molar KCl  
10 is 12,880 and this is the conductivity of 100th molar, so  
11 you might want to correct that for standardization purposes.

12 HALPERT: I have a comment regarding the same thing.  
13 The value of the concentration is in error and the value of  
14 specific conductance is in error. And the correct numbers  
15 are listed.

16 Okay. I am sure that will be corrected.

17 5.1.4 which deals with the silica content in the  
18 water. A comment regarding whether this is -- need a  
19 definition as to whether it is a silica, silicates, silicone  
20 or silicone as silicates, and I am not myself certain at this  
21 moment what is intended as that silica content. Maybe some-  
22 body has some comment about the silica content. We know that  
23 we had some trouble, and barring the fact that -- we are  
24 talking about separators today, we know that the separator  
25 can be a source of silica based on the way it is processed, so

1 I wonder if anybody else has a comment regarding silica or  
2 silicon or silicates.

3 (No response.)

4 HALPERT: I trust by your quietness that you think  
5 it all ought to be removed; is that right? Anybody see any  
6 need for it?

7 HFNNIGAN: I just recently saw a patent where  
8 silicates did improve battery performance. They didn't say  
9 how much. One of these paper patents again.

10 (Laughter.)

11 HALPERT: Okay. 5.1.5, I don't have a comment on  
12 that one.

13 5.1.5 dealing with the solids content of the water  
14 and the total organic materials. What we are essentially  
15 doing in this whole section is just specifying what we mean  
16 by deionized water. Is there any comment other than these  
17 about the deionized water?

18 NIFTZEL: A comment about organic matter. I thank  
19 you may want a spec relating to color. That would help solve  
20 that problem.

21 FLFISCHER: It might.

22 HALPERT: Okay. We go to the electrolyte area,  
23 5.2. —

24 FLEISCHER: I would like to make a comment about  
25 this, the association of official agricultural chemists have

1 standards for methods of determination of all the constituents,  
2 in water, and I think all we need to do is pick out the items  
3 we apply and say this is the specification that we shall use.  
4 It gives the limits and also gives the methods of determina-  
5 tion, and they keep them up to date. They are constantly  
6 revising them so they are up to date. So I don't think this  
7 should be done any other way than to accept what is known by  
8 the association.

9 PPEUSSF: I think you forgot to read our comments  
10 on 5.1.6.

11 HALPERT: Yes. Right. I had forgotten that.  
12 5.1.6. Since the solid content of the water is in the range  
13 of 10 to 20 ppm extraction of organics from this small amount  
14 of solid residue would require an initial quantity of water  
15 which would be extremely large.

16 Did you want to make any comment other than that?

17 PREUSSF: No.

18 HALPERT: Okay. Now we all know what water is and  
19 how we are going to use it. We will go on to the electrolyte  
20 and see how we can dilute it.

21 5.2, 5.2.1 are pretty straightforward. That should  
22 be available from the manufacturer.

23 5.2.2. I have comments. Electrolyte concentration  
24 can and should be held to plus or minus .25 percent. There is  
25 a limit that we can look to as a number.



1           5.2.2. Another comment. This will require a  
2 different procedure from that presently used. It would mean  
3 that the electrolyte would have to be bought in 55 gallon  
4 drums. The cost I am sure would go up over the present car-  
5 load lots. I don't think I understand that. Does that mean  
6 a mercury cell grade is not available in carload lots?

7           FLEISCHER: It is available in truck lots and tank  
8 car lots.

9           HALPERT: Okay.

10          NIETZEL: Truck lots run 2000 gallons.

11          HALPERT: Okay. Another comment. Either deionized  
12 or distilled water should be permitted for mixture of electro-  
13 lyte.

14          Anything else? Anything else on the mixture or the  
15 tolerances?

16          (No response.)

17          HALPERT: Okay. 5.2.3. A comment from Mr. Reed  
18 on the data showing the carbonate concentration is .01 grams  
19 per liter and less than that is normally obtained by the  
20 method described.

21          Dr. Reed, do you want to talk about that?

22          REED: Just briefly. We have made ordinary  
23 laboratory measures using the deionized water diluting 45  
24 percent koh down and we got in the order of 2, 3, possibly  
25 4 grams of potassium carbonate per liter. I made some other

1 with a little more care using distilled water, triple-distilled  
2 from alkaline permanganate under nitrogen and get down around  
3 .2 or .3 of a gram per liter, and when you get down this far  
4 I think it is very difficult to determine the amount of  
5 carbonate by this method, the double titration method, because  
6 the amount of acid required to go from the phenolphthalein  
7 to the methyl purple end point is very small unless your acid  
8 concentration is very low. And meanwhile if you are using  
9 low acid concentration you are using a very large quantity  
10 of acid to titrate the koh. I think we are perhaps putting  
11 the carbonate concentration lower than is either necessary  
12 or reasonable.

13 HALPERT: Do you have a method which you would  
14 suggest that we could use?

15 REED: No. I think the method is good but not for  
16 determining this low a concentration. In other words, if we  
17 are talking of the order of somewhere between .5 and 3 or 4  
18 grams per liter, then the method is quite good and the accuracy  
19 should be sufficient.

20 HALPERT: Okay. I have another comment with regard  
21 to that. The specified carbonate concentration interpreted  
22 as grams of carbonate as  $\text{CO}_3$  minus the carbonate ion exceeded  
23 the level presently supplied as mercury cell grade koh. The  
24 level of carbonate ion can be as high as .03 percent as  
25 potassium carbonate or as 45 percent koh, if I interpret this

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1 correctly, to be approximately .2 grams of carbonate per  
2 liter. By diluting to 30 percent this value does not decrease  
3 to the requested .01 grams per liter and is more in the order  
4 of .01 mohls per liter.

5 DUNLOP: I have got a comment. Two comments, really.  
6 One is that if you put any additives in your electrolyte  
7 then you have to change this procedure slightly or do some-  
8 thing else to determine how it affects what you determine by  
9 the titration.

10 Secondly, we did some work with W. R. Grace and I  
11 think we have a method to become slightly more accurate in  
12 the carbonate by the double titration. I don't want to  
13 describe that right now, but I would like to propose it to  
14 you and show you what we did there. I think it is a little  
15 more accurate way to do it.

16 HALPERT: Any other comments with regard to 5.2.4?  
17 5.2.3?

18 FLEISCHER: Before you go on, maybe we can call  
19 Tommy King to tell us what they use because they have been  
20 through this problem so exhaustively.

21 KING: Well, as far as the carbonate is concerned,  
22 we have been working on that problem since about 1952 and  
23 have reached this conclusion, that for any battery to give  
24 good performance it should be quite low, and for all our  
25 cells we are calling up less than 4 percent.

1           Now, the titration method we use is the double end  
2 point as referred to earlier and this has proven out quite  
3 satisfactorily. However, there are interpretations of how  
4 it should be done and I wouldn't like to get into that  
5 discussion just now, but we have had good success with it  
6 and we can detect pretty accurately our carbonates two ways.  
7 One is by the performance of the battery, by its voltage,  
8 and the other is confirming it by the analytical method.

9           DUNLOP: Right. We did the same thing. It worked  
10 very well.

11           HALPERT: Is there a limit that you use?

12           KING: Less than 4 percent or lower. The lower it  
13 is the better it is.

14           FLEISHER: That is 4 percent by weight so you have  
15 a density of 1.3.

16           KING: Beg your pardon?

17           FLEISCHER: The density of 30 percent --

18           KING: That is right. Less than 4 percent by  
19 weight or less than 2 equipments. Two equipment percent I  
20 should say. That is what we aim for, and for any of our  
21 batteries, regardless of what they are, we call for that and  
22 one of the reasons is that if we get above that we don't meet  
23 our low temperature environmental requirements that we need  
24 in Canada. I am talking about all batteries, aircraft, et cetera,  
25 as well as spacecraft.

1 HALPERT: Thank you.

2 Is there something else?

3 SULKES: It would appear that the .01 is so far out  
4 of line with -- let's see, he would have -- Dr. King -- 50  
5 grams per liter of carbonate.

6 FLEISCHER: Fifteen.

7 SULKES: Fifteen. And also the volts you would get  
8 even on the normal handling, perhaps you are about 2 orders  
9 of magnitude out than what you are really asking for.

10 STEMMLE: A comment here. This past summer I was  
11 doing some reading in Pierce, Haynes and Sawyer's biometric  
12 analysis book and one of the ways that they suggest to make  
13 carbonate-free alkaline solutions is to start with concentrated  
14 sodium hydroxide. Apparently this biometrically analytically  
15 removes all the carbonate. So my question here, which may  
16 not be appropriate, but would it be possible to arrive at a  
17 carbonate-free electrolyte by mixing in a small fraction of  
18 sodium hydroxide?

19 RFED: The clue here, of course, is that sodium  
20 carbonate is quite insoluble in sodium hydroxide, but the  
21 case is not similar with potassium carbonate and potassium  
22 hydroxide. You have a very high solubility of potassium  
23 carbonate in potassium hydroxide. The only way I know of to  
24 get rid of it if you have it in is to precipitate it with  
25 barium hydroxide and you may not want to add the barium ion

1 to your electrolyte.

2           STEMMLE: Well, my question would be is sodium  
3 carbonate soluble in potassium hydroxide? It may be that it  
4 is not and you could get rid of the carbonate this way.

5           HALPERT: All right, we go on to 4.2.4. The  
6 comment I have, are these specific ion electrodes commercially  
7 available and are they effective in concentrated alkaline  
8 solutions?

9           I can say that the nitrate one is available and  
10 the chloride one is available. We have not finished enough  
11 test methods to know whether they are active or whether they  
12 will work in a high concentration of alkaline.

13           Some information. There is some test data on these  
14 specific ion electrodes. Do we have anybody here who might  
15 be able to comment on that?

16           GASTON: I have been informed that the ions  
17 electrical electrode does not perform too well in a high  
18 concentration and so we chose a colormetric analysis instead.  
19 I don't have all the details to actually answer your question.

20           HALPERT: Does anybody have anything else now on  
21 the 5.2 series on eletrolyte or the water content? Any  
22 comments? Any comments regarding this?

23           (No response.)

24           HALPERT: Okay. Going to No. 6 which is the metal  
25 container. In Section 6 I have a comment. We presently use

1 neither stainless steel nor pure nickel. Stainless steel  
2 presents a danger to the electrolyte for a potential exists  
3 chrome will pass into the solution. For cells with 12 amp  
4 hours and above we utilize nickel-plated stainless steel  
5 containers which are formed by a press and have no welded  
6 seams.

7 Another comment regarding Paragraph 6.1. 304 stain-  
8 less steel should be permitted as well as 304L stainless  
9 steel.

10 A comment regarding 6.0 or 6.1 which regards the  
11 material. Anybody have any information with regard to 304L  
12 or 304?

13 CARR: We use stainless steel drawn cans in our  
14 space batteries and we have had quite good success. We are  
15 using the 300 series. I think maybe this ought to be broadened.  
16 We are using actually 305. Exactly why I don't know, but we  
17 are.

18 ALPERT: Any other comments with regard to that?

19 Yes, sir?

20 CORBETT: I have a question as to why in the early  
21 part of the spec, which I did not comment on at that time,  
22 why nickel is the preferred material and why stainless is not  
23 the preferred material for plating and if so, why should it  
24 be different for the case material, especially if you are using  
25 a third electrode which is in common with the case?

1 SCOTT: A practical question regarding 304 versus  
2 304L. We note that 304 is available in stock at the mills  
3 in the gauges that are now being used for making cell cases  
4 whereas 304L is not and requires special mill runs and there-  
5 fore there is a definite problem of scheduling and availability  
6 for 304L that does not exist for 304.

7 HALPERT: Can I ask, Will, if you know whether  
8 there will be a problem with dimensions, with handling of the  
9 304L versus the 304, if they had to make special mill runs?  
10 Do you have any feeling for that?

11 SCOTT: Do you mean maintain dimensional tolerances  
12 on the special runs?

13 HALPERT: Yes, right.

14 SCOTT: I can't comment on that. I am not aware  
15 of any problems that have come up.

16 HALPERT: As I understand -- to clarify for those  
17 who don't know the difference, it is mainly in the carbon  
18 content. I think it is -- no, I don't know the tolerances  
19 right now. 304L being a lower -- being lower in carbon  
20 content than the 304.

21 FLEISCHER: Does it have columbium in it?

22 CARR: That is 3.2.1, Art.

23 HALPERT: Does columbium present a problem that you  
24 know about?

25 FLEISCHER: No, no. It is usually put into the



1 welding rods, in gas welding, so that you don't have carbide  
2 precipitation and that is why you want the low carbon. If  
3 you have carbide precipitation with stainless steel welding  
4 you have corrosion problems.

5 SCOTT: I am not convinced that there may not be a  
6 number of other alloys in this series that are suitable for  
7 this use. I am not sure why just the 304 and 304L are the  
8 only ones that have been used. It seems to me that selection  
9 might be broadened if you really took a look at the whole  
10 supply question.

11 HALPERT: Do any of the manufacturers want to  
12 comment on 304 and 304L or other materials that they might  
13 be using as to why they chose those?

14 CARR: Probably the reason we are using 305 is  
15 improved drawing ability. These are drawn containers. And  
16 with respect to drawn containers, it is not possible to hold  
17 the tolerances in 6.5. There are two different types of  
18 tolerances that have to be allowed and one is the basic  
19 tolerance on the tool and then in removal of the part from  
20 the tool they sometimes I guess use air pressure or other  
21 techniques which may introduce another slight deformation of  
22 the can. So these things have to be taken into account and  
23 I think we are probably more in the order of a total tolerance  
24 of around thirty-thousandths.

25 HALPERT: Anyone else on that subject?

1 HENNIGAN: One company here has said -- was it  
2 chromium, they would rather not use chromium because of stain-  
3 less steel? Does chromium really have a problem with nicad  
4 cells or not? Shall we worry about it?

5 FLEISCHER: Jerry said that we shouldn't dig up  
6 any folklore.

7 (Laughter.)

8 FLEISCHER: But this is one case where there is  
9 some -- at Edison they insisted that chromium contamination  
10 of the cadmium negative active material will lead to loss of  
11 performance, especially in capacity.

12 Now, this is the only thing I know. I couldn't  
13 find any evidence that it had been experimentally tested or  
14 what the experiments were on which they drew this conclusion.  
15 That is the only evidence that I know of.

16 GROSS: I don't think that titanium cases are a  
17 completely dead issue and I would think it would be worthwhile  
18 to not exclude them at this time.

19 STEMMLE: What about a nickel case? If stainless  
20 steel has chromium in it, what about considering using nickel?  
21 Is it a matter of not sufficient strength or not equal strength  
22 to stainless steel or nonavailability due to the strike or  
23 what?

24 HALPERT: That is suggested in the spec.

25 YEKES: Maybe some of the prime satellite

1 manufacturers could make some comment about the desirability  
2 of drawn cases for heat transfer reasons in battery building  
3 versus the all-welded cases. Is there a strong desire to  
4 have drawn cases? Dr. Scott?

5 SCOTT: Jerry, would you rule on the -- would you  
6 rule on whether that is a point of order or not right now?

7 (Laughter.)

8 HALPERT: No, I can't.

9 (Laughter.)

10 HALPERT: Let's go on to the next question.

11 (Laughter.)

12 HALPERT: No, I don't think it has really been  
13 determined, at least to my -- I don't know whether I can  
14 answer it scientifically. I think it is just another place  
15 where we have a problem with weld there and a place for a  
16 leak. And as it is drawn it leaves you a little -- yes, okay,  
17 so you don't have that chance for a leak under those conditions

18 YEKES: They are changing materials because you want  
19 drawn cases.

20 HALPERT: No. He says he is using 305 instead of  
21 304 because it draws better, he thinks. And we are discussing  
22 the case materials which you are ruling on here. And I am  
23 curious as to how important it is to have drawn cases and are  
24 there some valid demands that are apparently moving some of  
25 the battery cells to be in drawn cases instead of double-ended

1 welded cases? Is it just a welding, inches of welding  
2 problem?

3 SHERFEY: The welded versus the drawn can used  
4 to be a matter of weight. There is a significant weight  
5 saving in the case of the drawn can. As far as I know this  
6 is no longer critical in the present spacecraft. But that  
7 was the original reason for going to the drawn can.

8 I think perhaps the reliability in terms of leakage  
9 in the drawn can would be higher than that of the welded can.

10 THIEPFELDER: I just want to add one thing. When  
11 we went to the drawn can it was to remove the burr from the  
12 bottom of the cell because this was a problem in packaging  
13 the cells. So when there was a weld around the bottom that  
14 gave an additional burr to worry about.

15 HALPERT: Any other comments?

16 GASTON: My concern about the drawn cases if if you  
17 have a tall narrow case it is the inside taper and the effect  
18 of pressure so with drawing cases you have to look at the  
19 dimensions and see how much of a taper or how little of a  
20 taper because you like to have very little taper or none, but  
21 that is not practical in drawn cases, so you have to consider  
22 that in each specific design.

23 CARR: In line with Steve Gaston's comment, I  
24 think that the specification should include both drawn  
25 containers and fabricated containers because there are shapes

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1 you cannot draw. Period.

2 Now, one other thing I would like to say is that  
3 in reading through the section on the ceramic seal I did not  
4 see where the cover material was called out. I may have just  
5 missed it. But, again, we would like to broaden that to the  
6 300 series because we use -- instead of 304 we use 303 because  
7 it is a better punch part material.

8 HALPERT: Any other comments with regard to 6.1?

9 (No response.)

10 HALPERT: 6.2. I have a comment. To conform to  
11 trade jargon batch number should be replaced by heat.

12 Okay. Any other comment as far as 6.2 is concerned?  
13 Certified analysis. Is everybody happy with that?

14 (No response.)

15 HALPERT: Okay. 6.3. Again here I have a comment  
16 that batch number should be replaced by heat to conform to the  
17 trade jargon.

18 Any other comment with regard to that?

19 (No response.)

20 HALPERT: 6.4. Comment. Add if required after  
21 weld rod since not all welding processes require weld rod.

22 Any comment with regard to that and the MIL standard  
23 there, MIL spec?

24 (No response.)

25 HALPERT: Okay. On the tolerance on the can

1 thickness and depth and wall, two comments. The mil tolerance  
2 for material and the range of .025 inches to .030 inches is  
3 specified at plus or minus .003 inches to 2 plus or minus  
4 .004 inches. Thus in specifying these tolerances a rework  
5 operation would be required.

6 Another comment. Wall thickness of plus or minus  
7 1 mil can only be applied to sheet stock and would be very  
8 difficult to obtain on a drawn container.

9 Any other comments with regard to the wall thickness  
10 of the can itself and the prismaticity of the can if we are  
11 talking about a prismatic can?

12 (No response.)

13 HALPERT: I don't know whether it is realized here  
14 that we do get cans that have a great degree of inward bulge  
15 to them, and it does create stress on the plates and in the  
16 separator in the internal parts of the cell and I think it  
17 does have a definite effect on, or could have a definite  
18 effect on heat effects in the cell and therefore life. I  
19 wonder if anybody has ever thought about that or done any  
20 work along those lines to try to achieve a prismatic can, a  
21 truly prismatic -- or at least spec that part of the can.

22 (No response.)

23 HALPERT: Okay. We will go on to 6.6. Each can --  
24 I am sorry, on 6.6 I have a comment. Since some defects are  
25 always present visual standards must be set. Also specifications

1 should not allow brinding of weldments and other operations  
2 such as satin finishing and vapor blasting which are performed  
3 for cosmetic reasons.

4 Another comment -- no, I am sorry.

5 Any comments with regard to defect-free cans?

6 CARR: There is this thing about vapor blasting.  
7 In order to do an effective helium mass spectrometer test we  
8 find that we have to liquid hone the completed cell. So we  
9 do our leak check after a liquid hone. The liquid hone is  
10 also done for adhesion whenever we are using an encapsulation  
11 procedure to install battery cells.

12 HALPERT: Any other comments on this aspect on the  
13 outside of the can? The looks.

14 GASTON: I have one more comment. In my specifica-  
15 tion I see a passivation of all the welded areas to MIL-F-14072  
16 finish F-300. I cannot explain at the moment why we have a  
17 passivation. Maybe it is something to be considered.

18 In addition, the weld penetration, some criteria  
19 should be set as to the penetration of the weld on the welded  
20 area.

21 HALPERT: Anything else on the can or the container?

22 SCOTT: Yes. Unless it is somewhere else where I  
23 haven't been able to find, I think something should be in here  
24 on cleaning of the internal surface of the container before  
25 insertion of the plate stack. And I think that process should

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1 he specified or described in the information available.

2 HALPERT: Any other comments with regard to this?

3 (No response.)

4 HALPERT: Okay. Again -- we have now finished 6  
5 and we would like to wait a little while before we get into  
6 the ceramic to metal seal, so in lieu of this we would welcome  
7 any comments again on the general nature, philosophical nature.  
8 I understand there were a couple of people who did want to  
9 say something earlier today that did not get a chance to do so.  
10 Now is a good chance for you to speak up.

11 STEINHAUER: Back on this cost question. This  
12 morning it seemed that the cell manufacturers were quite  
13 concerned with cost. The aerospace manufacturer is, too. But  
14 recognize that this nickel cadmium battery is normally the  
15 low reliability item of the spacecraft. It is also a  
16 relatively low cost item in comparison with the solar panel.  
17 And this is a life-limiting thing for the spacecraft. I think  
18 we can afford to put a few more dollars into the reliability  
19 of a long-life battery than we are currently doing and I don't  
20 think that the comments or the specification that we are  
21 working on should be limited, at least at this point, by an  
22 extreme concern on cost.

23 HALPERT: Any other comments?

24 RAMEL: I want to refer to Specification 2.4 on  
25 individual plate determinations. It seems that the



1 determinations are related to capacity measurements and nothing  
2 else.

3 If the reason for that is to get an idea of capacity,  
4 frequency or negative-positive ratio I would like to say that  
5 the negative-positive ratio varies with the current density  
6 and the temperature and the number of cycles.

7 And Item No. 2 is that those tests for capacity  
8 give no information whatsoever as to the oxygen recombination  
9 rate of the negative.

10 HALPEPT: Comment along these lines? Questions?

11 (No response.)

12 HALPERT: With regard to oxygen recombination, I  
13 might make this one statement. It looks like we are going  
14 in the direction of having that as not as serious a problem  
15 as we used to have since we are now depending on various types  
16 of charge control devices, third electrodes, coulometers,  
17 strain gauges, and it seems that oxygen recombination may not  
18 be as great a problem as we have been led to believe early  
19 in the game, that we heard about early in the game.

20 KUHN: Perhaps the point he was trying to make may  
21 be that regardless of the importance of oxygen recombination  
22 you might use it as an easy criterion, as a test criterion as  
23 to the behavior of the product, the quality of the product.

24 FORD: I wholeheartedly agree with that comment.  
25 That is one area in this spec that has been totally omitted

1 and I think there is a very big need to use this as a  
2 screening criteria in the production of the cell. And this  
3 becomes extremely important in third electrode type charge  
4 control, is the ability of the negatives to handle the oxygen  
5 and recombine it in an effective manner. And I think there  
6 is a place in the processes that I understand at this point  
7 that this could be used, and as a screening device.

8 What I am saying, it is going to appear in the  
9 spec later on.

10 (Laughter.)

11 HALPERT: Anybody else comment in general?

12 GROSS: I have a minor comment. Item 2.3.1 where  
13 plates are to be put in containers, I wanted to point out  
14 that some plastics will pass carbon dioxide vapor fairly  
15 readily, so the container should specifically exclude the  
16 passage of CO<sub>2</sub>.

17 KING: I would just like to say that we are still  
18 stressing oxygen recombination, even though we are using  
19 charge control devices in the event that such a device should  
20 fail. We still would be assured of long runouts by our  
21 battery, and we will stick to this recombination for a long  
22 while to come I believe.

23 DUNIOP: I think Dr. Pampel from GE was bringing  
24 up a point that what you have in a cell when you first test  
25 it may vary a great deal from what you might have in a cell

1 after it has run under certain conditions and for a certain  
2 number of cycles, et cetera, et cetera.

3 I think, though, that the intent here is to find  
4 out what you have in the cell to begin with and then you can  
5 do what Dr. McCallum was trying to do, and that is figure out  
6 what kind of failure analysis you go into after the cell has  
7 gone through some kind of time history effect. But if you  
8 don't know what you had to begin with then you haven't got a  
9 very good baseline to compare what the effects of different  
10 cycle or temperature or performance is.

11 The other point I would like to make is I am sure  
12 everybody here realizes the importance of the oxygen  
13 recombination effect and we don't want to write that one off,  
14 with third electrode charge control.

15 One more point. I am going to start talking here  
16 since I haven't made much noise yet today. I did -- sitting  
17 across the table from Steinhauer when they went through the  
18 design review on Intelsat 4, it was very interesting to note  
19 that for the power system the reliability of the power system  
20 was determined almost on reliability of the batteries. This  
21 is the reliability analysis for the entire power system  
22 including the charge control, the regulation for the entire  
23 spacecraft load, the solar arrays, everything that you could  
24 consider in the power system for the satellite, and that  
25 reliability number for a seven-year lifetime was identical

1 almost to the reliability for the batteries because the  
2 batteries are so much worse than anything else you put in  
3 there.

4 FORD: Jerry, I would like to make one other  
5 comment. One thing has become quite obvious in the past  
6 couple of years in regard to this negative-positive ratio,  
7 the over-charge capability of cells, et cetera.

8 The approach in the past has been to design a  
9 cell over a broad temperature range, take one item, one  
10 design and use it for all applications. It is becoming more  
11 and more clear with passing time that this is not necessarily  
12 the best way to go.

13 What I am trying to say is simply this, that a  
14 satellite, like a communications satellite, that is going  
15 to present an environment to a spacecraft battery of 60 to  
16 90 degrees F. would not necessarily use the same cell design  
17 as a satellite that you can give a battery a zero to say 32  
18 to 50 degree F.

19 I think we have this information at our fingertips  
20 and we are just beginning to realize that it becomes a very  
21 useful parameter in long-life batteries.

22 SUHKES: Going back to something specific, 2.4.2.8,  
23 it calls out a paragraph and I can't seem to find it. What  
24 it means, to cut them to cell size and coin them to proper  
25 size.

1           WALPERT: 2.1.1.1.9 instead of 2.1.1.6.

2           FLRISCHER: I would like to go back to Rampel's  
3 oxygen recombination determination. We do actually have in  
4 Section 8.8 an over-charge test in which the cell on-charge  
5 voltage is specified and in a way this is an oxygen recombina-  
6 tion test, but I wasn't quite sure whether you propose that we  
7 measure the oxygen recombination of the individual negative  
8 plates or of the cell as assembled. So if you have a method  
9 I think everybody would like to hear it.

10          RAMPEL: What I was referring to is that it is just  
11 as important to consider that as it is to just consider  
12 capacity per se in those individual plate measurements. But  
13 in the individual plate measurements which I imagine the  
14 most important aspect is to decide on the negative-positive  
15 ratio I think that we have to be aware of the fact that the  
16 negative-positive ratio changes depending upon the rate of  
17 charge discharge and the temperature, because of the charging  
18 acceptance of the positive at the cold end compared to the  
19 hot end and what happens to the negative plate at the hot end.  
20 It faces. And the number of cycles that is conducted. I  
21 think those things have to be spelled out because otherwise  
22 the negative-positive ratio as determined at room temperature,  
23 you may still get into trouble at other temperatures.

24               Specifically answering your question, though, on  
25 the oxygen recombination, yes, I do think that each negative

1 plate lot should be -- the recombination rate should be  
2 decided early in the game.

3 HALPERT: In answer to that one point, we not  
4 only measure the capacity of the electrodes, we also measure  
5 the oxygen free charge capacity and the high energy free  
6 charge capacity and negative and hopefully some of these  
7 physical measurements that we make on both the positive and  
8 the negative will relate back to some oxygen recombination  
9 rate that we hope under the controlled conditions would be  
10 fairly uniform. We are not sure that it will be, but it  
11 might be a help in that regard, rather than trying to measure  
12 them on an individual plate which would mean very little  
13 inside the cell as you have just said.

14 BELOVE: Continuing on what Guy Rampel said, it is  
15 our feeling that the negative-to-positive ratio is important  
16 and should not be considered in the realm of 1.2 to 1.4 to 1,  
17 but higher.

18 We have gotten into working much higher ratios  
19 than that for the very simple reason that you do not always  
20 know the environment that the battery is going to be used in,  
21 nor do you know the exact current density on charge or discharge  
22 These are varying factors in many of the uses in satellites  
23 and for that very reason that ratio must be greater than what  
24 is prescribed, the usual 1.2 to 1.4 to 1.

25 GROSS: In referring to negative-positive ratios,

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1 I think we have to distinguish between the theoretical ratios  
2 and the ratios of what you get in the flooded test.

3 Secondly, with regard to the measurements on oxygen  
4 free capacity and hydrogen free capacity it is known, of  
5 course, that these are functions of rates and temperatures  
6 and the state of charge, a variety of things, and we have to  
7 consider the complex functions that these relate to in asking  
8 for this requirement and pick a condition at which we want the  
9 test run.

10 KING: Continuing on the subject of the overcharge  
11 and oxygen recombination, I might mention that we test all  
12 our cells from plus 40 down to minus 5 to minus 12, and the  
13 test at minus 5 and minus 12 is 120 hours of overcharge at  
14 the C over 10 rate without the pressures rising above 75 psi  
15 as measured. And we have been running as low as 30 psi after  
16 the 120 hours.

17 FORD: Is that degrees F?

18 VOICE: What temperature?

19 KING: Degrees C.

20 CORBFTT: On Mr. Green's comment I would like to ask  
21 him what kind of voltage you expect to see at those low  
22 temperatures. Do the numbers stick in your mind there?

23 KING: Yes. If the voltage exceeds 1.5 at minus  
24 5 degrees centigrade the cell is considered rejected.

25 STEINHAUER: Dr. King, do you run into any problem

1 with hydrogen at minus 5 C in a C over 10 charge? Does this  
2 pressure recombine?

3 KING: As far as we can detect, and we have made  
4 measurements on this, there is no hydrogen being evolved from  
5 our cells. We have had hydrogen evolved at other temperatures  
6 under other conditions and have identified it as such, but at  
7 minus 5 on the cells I am talking about, no.

8 CORBETT: I have one more question to Dr. King.

9 Is this the end of charge voltage or is this the  
10 peak voltage reached at any time during the 120 hours?

11 KING: The 1.5 volts is the end of charge voltage  
12 at the 120 hour mark. Occasionally we have seen a slight  
13 rise and we do allow up to I believe it is 1.57 for a period  
14 up to the first 7 hours and after that the cells have to  
15 settle down to the 1.5 or lower.

16 Usually the cells are running about 1.53, so that  
17 we are well below our cutoff voltage and at the higher  
18 temperatures we are looking at 1.45 volts.

19 HALPERT: Anyone else want to comment or make some  
20 general comments?

21 We are kind of stalling here, as you can gather.  
22 Coffee is about five minutes to go and we would rather not  
23 start something and then have to get up and leave it.

24 With relation to some of the comments that someone  
25 has made on the tests, I think that once we are able to



1 reproduce some of our basic material in some of our plates,  
2 when we do start looking at the plate materials in terms of  
3 the optimum type of cycle, whether it be a synchronous orbit  
4 or 30-60 type of orbit, we can design better and make better  
5 designs of our plates, but at the moment since we have plates  
6 that still do vary quite a bit and one group is so much  
7 different than the other we still cannot base any particular  
8 measurement or design change. That is it is difficult to  
9 make these changes based on the end design of the cell. And  
10 hopefully by the time we get finished with this we will be  
11 able to implement some of these changes and some of these  
12 controls so we will get uniform materials that can be  
13 reproduced from time to time and then know better where we  
14 sit with regard to how the cell is actually working under a  
15 given set of conditions.

16 KING: Just one correction. I said -- I believe I  
17 said 1.5 volts. It is 1.55 at minus 5 degrees.

18 HALPERT: I think everybody breaths a little bit  
19 easier.

20 GROSS: I want to help you use up some of your  
21 extra time. I will make this comment that I didn't see in  
22 the spec any requirement as to whether the tabs were to be  
23 attached after impregnation or before. I would prefer to  
24 have it done before. There are some problems that you can  
25 get into I think you can understand if you do it afterwards.

1 HALPERT: I think there was some discussion --

2 FORD: I believe if I recollect that somewhere  
3 in here it is stated that the tabs shall be an integral part  
4 of the grid structure, of the metal structure. I know that  
5 does not apply equally, but that has been considered.

6 CARR: As most of you are aware, our tabs are not  
7 an integral part of the plate structure and we do put them on  
8 after we cut the plate. In fact, we punch the plate. The  
9 process here, again -- this gets into an area I think where  
10 we don't care to argue our process against someone else.  
11 Again, it has its advantages and its disadvantages. But there  
12 if, like Dr. Fleischer says, you do it right, it is good.

13 (Laughter.)

14 HALPERT: You attach the tabs to the plate and not  
15 the plaque; is that right?

16 (Laughter.)

17 STEINHAUER: Since we have a few minutes I didn't  
18 want to leave Jim Dunlop's comments completely unanswered on  
19 reliability, but I think there is one thing we have to look  
20 at and perhaps Dr. McCallum can comment. Our reliability  
21 predictions are only as good as the data that we can put into  
22 them and we have that cream type of data, we have telemetry  
23 type of data and we are talking about five and ten-year mission  
24 now. We haven't any real time testing on these nicad batteries  
25 out to that point and therefore our reliability predictions

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1 may be somewhat more pessimistic than they might be if we  
2 had more data.

3 DUNLOP: They may be optimistic, too, you know.

4 (Laughter.)

5 STEINHAUER: That's right.

6 HALPERT: I did hear one comment this afternoon  
7 one of the manufacturers made and that is that they really  
8 don't get a feedback of some of the aerospace data on batteries  
9 and they really don't even know how their own batteries are  
10 doing in space, and I think this may be a lack or break in  
11 the communications somewhere. I think they should be fed  
12 back. We want as much information as we can get from them.  
13 We certainly want to feed them back information on how their  
14 materials are doing

15 STEINHAUER: They hear about the failures.

16 HALPERT: And the failures did you say?

17 STEINHAUER: I said they hear about the failures.

18 HALPERT: Yes, they do.

19 HENNIGAN: I would like to comment on that.

20 Normally we don't get too much information back on batteries  
21 until they get in trouble, and this is when they get on  
22 failure design review committees.

23 One thing I would like to mention too about the  
24 cost -- I have been in several that failed like in integration  
or during a procurement -- not procurement, during integration

1 and maybe even at the launch pad, and these are very expensive  
2 items. We kind of figure the OAO was costing at least a  
3 million dollars to turn around. Is that a ballpark figure?  
4 To get a new battery. Now, this wasn't for the battery, this  
5 is because you are holding up the Cape, you are holding up  
6 thousands of people in this country waiting for something.  
7 They don't have anything to do in the meantime unless the  
8 spacecraft is on schedule. So there is where your expense  
9 comes if you have battery trouble.

10 GASTON: I have a comment. I would like to make  
11 one correction on what Tom Hennigan said. The OAO spacecraft  
12 was not held up because the batteries were late. There were  
13 other items which were late. The OAO was launched on schedule.  
14 It was not the battery that held it up.

15 HENNIGAN: It cost a little more.

16 HALPERT: Hopefully the coffee is ready out there.  
17 We will break and then come back and talk about ceramic metal  
18 seals.

19 (Pecess.)

20 HALPERT: I would like to continue on this afternoon  
21 in the ceramic to metal seal area, and at this point I would  
22 like to turn the meeting over to Bob Steinhauer of Hughes who  
23 has done a great deal of work in this area.

24 Bob Steinhauer.

25 STEINHAEUP: Thanks, Jerry.

1           The spec has been written to an active metal  
2 process and we are quite aware that there are people using  
3 the mullimanganese(?) process and it is not an intent to  
4 exclude that.

5           We have some comments that have been sent to the  
6 Committee on 4.1.1 that there should be a list of approved  
7 ceramic bodies and suppliers. And to add the specific  
8 gravity in 4.1.2.

9           Are there any comments on that?

10          CARR: Exactly how is this going to be determined?

11          STEINHAEUER: Well, this spec as written of course  
12 calls out I believe a 99.4 percent body. There are several  
13 that are being used and we may want to list specific suppliers  
14 and the approved body that has been done previously in vacuum  
15 tube industry.

16          CARR: Would you do this rather than include the  
17 requirements for the ceramic in a specification? I don't  
18 quite understand. In other words, in writing the specifica-  
19 tion is it going to have the requirements for the ceramic in  
20 it or is it just going to have the vendor's name and his part  
21 number? This seems to me to defeat what we are trying to do  
22 here.

23          STEINHAEUER: If it is to be all-inclusive we would -  
24 this could expand the spec quite a bit. I think there are  
25 specs already on ceramic bodies that could be referenced.

1 CARR: I understand. We are working with a vendor  
2 and I guess we work with 94 percent, 97 and 99 percent in our  
3 programs right now. We would be glad to furnish this infor-  
4 mation for the spec review or additions to the spec.

5 STEINHAUER: I appreciate that.

6 UBANKS: I have a question about the 99.4. As he  
7 points out, 96 percent and 94 percent have been used to make  
8 good seals. Is the purpose for this 99.4 because of the glass  
9 content or the lower alumina(?) content so that you do have --

10 STEINHAUER: That is the specific concern, yes.

11 UBANKS: So you don't want to use anything but 99.4?

12 STEINHAUER: I think this has yet to be resolved  
13 because we do have proven seals used on these nicads with a  
14 96 percent body, and I think we would definitely want to  
15 entertain further comment -- further information to the  
16 committee on that.

17 UBANKS: Well, I am assuming that the 99.4 percent  
18 is because of the lower glass content, therefore you don't  
19 get the attack. Maybe that is the reason that you put that  
20 in there.

21 STEINHAUER: Yes.

22 VOYNTZIF: I think the main point here is just what  
23 the remaining impurities are. I am not certain that the  
24 .6 percent versus the few percent and the 96 percent make a  
25 difference. It depends exactly what these impurities are and

1 how they are attacked. The 96 percent works excellently.

2 STEINHAEUER: Usually the major percentage is silica  
3 on the lower bodies.

4 BFLOVE: Another comment relative to what we have  
5 spoken about before. Again, we are specifying a material.  
6 We are not putting down limits, or not asking for data, but  
7 we are now specifying ceramic.

8 Now, I have no grudge against ceramic. We have  
9 used ceramic and we are using ceramic, but I happen to know  
10 that there are plastic seals that are good, have proven  
11 excellent through the years. Nevertheless, this specifica-  
12 tion precludes the use of any seal other than that using  
13 ceramic. I don't agree with this concept of the specifica-  
14 tion.

15 STEINHAEUER: It is not the intent to exclude the  
16 other seals. This specification, as you realize, in the black  
17 area and in some of the areas that we discussed this morning,  
18 was exclusive there. It is not intended to be there nor here  
19 either. I think we would want information submitted that  
20 would give us information on the type of seal you are referring  
21 to.

22 FORD: You are saying -- the gentleman from  
23 Sanatoni(?) -- are you saying that the plastic seal is a  
24 proven space seal? Has it been used in space applications?  
25 Are you saying it has been used in battery manufacturing?

1           BELOVF: It has been made or used on batteries that  
2 were intended for space. Some have flown many years ago, but  
3 we still have batteries around in the laboratory that are  
4 showing no leakage after many, many years during which  
5 ordinary ceramic seals have shown leakage. And what I am  
6 saying is while we do not have space experience equivalent to  
7 ceramic, the seal appears to us, on a technical basis, appears  
8 to be worth while including in the specification, providing  
9 that the seal can meet some given requirement and if you  
10 specify that I can understand it. But what you are doing is  
11 specifying a material.

12           STEINHAUER: Any further comment?

13           GROSS: This specification is going to -- I think  
14 it is going to require some design changes, or at least  
15 manufacturing changes. With that in mind I would like to see  
16 a stress analysis of any new ceramic seal that is developed.  
17 I think that this is one of the reasons that we have leaks  
18 is because the engineering is not analyzed properly to begin  
19 with.

20           BREDBENNER: The seal design that is currently being  
21 used on battery seals has been used for over ten years under  
22 much more severe conditions than the battery seal is exposed  
23 to.

24           STEINHAUER: The one thing present of course is the  
25 electrolyte that you do not see in a vacuum tube application.



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1 On 4.1.2 we have a further comment. Is there a  
2 particular dye check procedure which is recommended?

3 I think almost any company you go into you will  
4 find a different one.

5 BREDBENNER: This is normally a requirement put on  
6 the ceramic manufacturer. The one I am assuming here is  
7 one that we would perform also to assure that he just hasn't  
8 passed it up. It is just a simple emersion in a fushine(?)  
9 dye. Then possibly taking these samples and breaking them  
10 for diffusion of dye into the ceramic.

11 STEINHAEUER: Before we --

12 BREDBENNER: One more comment on that. The dye  
13 check used by ceramic industries is under 4000 psi pressure  
14 normally, which is quite a severe test.

15 STEINHAEUER: We have, in addition to the comments  
16 that were submitted to the committee earlier -- Mel Bredbenner  
17 has submitted almost a complete specification to us for  
18 consideration for these metal ceramics which is quite detailed  
19 and a little too lengthy to go into here. It parallels, how-  
20 ever, what is in the spec but is a little bit more specific  
21 in certain areas.

22 Now, there are some comments that have been made  
23 on 4.1.2 making dye check after mechanical inspection but  
24 prior to 4.1.4, prior to the chemical cleaning. Is this an  
25 appropriate point to make the dye check? Any comments?

1 UBANKS: I think probably the reason for that  
2 would be that if it is going to be done by the ceramic  
3 manufacturer, this is one thing, because the part might get  
4 chipped or the dimensions may be wrong after the person who  
5 is making the seal gets them. But if the dye check is going  
6 to be made in-house, if a part does not meet the dimensional  
7 requirements it would be better to weed these out before you  
8 make the dye check.

9 STEINHAEUER: I have no comments for 4.1.3. This  
10 is on mechanical inspection in connection with chips, cracks.

11 BREDBENNER: I have one comment. I think the 100  
12 percent inspection is fine for everything there except for  
13 dimensions. I would suggest 1.AQ Level 2, MTL-STD-105D.

14 STEINHAEUER: We have a comment on 4.1.4, air dry  
15 at 120 centigrade after water wash as a recommended practice.

16 UBANKS: Could you -- I believe this is your  
17 comment -- could you give us the rationale behind that?

18 VOICE(?): Well, the reason I made that comment  
19 is because this is sort of standard procedure, is it not,  
20 that after chemical cleaning it should be air dried thoroughly.  
21 This may obviate -- I think it obviates the necessity of 4.1.5  
22 where you do the air firing after the chemical cleaning, but  
23 I think that air drying at 120 after the wash is necessary to  
24 get the parts completely dry before doing the air firing.

25 STEINHAEUER: But you do still recommend the air

1 firing?

2 VOICE: Yes.

3 BREDBENNER: After the dye check one step is  
4 necessary to take the dye out and this normally involves a  
5 nitric acid dip and in giving the nitric acid dip you also  
6 remove mental marks that might be on there. If you don't remove  
7 them at that time when you air fire you would burn them right  
8 in so it is necessary to remove the dye and any metal marks.  
9 And then this air firing should exceed 450 centigrade in order  
10 to burn off organics or else they will just turn to carbon on  
11 there. So the 1000 degree centigrade is fine. It is used on  
12 most high reliability jobs that I know of.

13 STEINHAUER: There is a comment that there should  
14 be slow cooling after this firing and then to store in  
15 polyethylene bags, but no longer than three days before  
16 metalizing. Clean ceramics must not come into contact with  
17 any metal parts during handling, tweezers, et cetera, are  
18 applicable. It should be bone-tipped or coated with plastic.  
19 Since all traces of metal marks, slivers, et cetera, must  
20 be removed to assure good metalizing. Some manufacturers  
21 boil metal parts in nitric acid for periods up to thirty  
22 minutes followed by rinsing and boiling in deionized water  
23 for thirty minutes prior to step 4.1.4. Care should be  
24 taken to protect ceramic parts from contact with pilot flames  
25 and gas flame curtains while entering or leaving furnace. Parts

1 should be fired in ceramic trays or plates, not in metal. Any  
2 comment on that?

3 BRFDBFMNEP: Obviously this describes a molybdenum  
4 process. The use of plastic-tipped tweezers is simply out  
5 because it can leave organics which don't burn off in a  
6 vacuum.

7 UBANKS: Well, maybe the term plastic should be  
8 removed. I would like to keep the burn tip in. What I am  
9 trying to do, in other words, is to keep the metal marks from  
10 getting on the ceramic part.

11 STEINHAUER: Another comment on 4.1.5. We do not  
12 see the technical justification for air firing. The alumina  
13 had been previously fired to form the ceramic cylinder and it  
14 is once again fired during the bracing operation.

15 Comment on that?

16 BREDENNER: It is probably not as important in  
17 molybdenum metalizing, but much more important where you  
18 are firing in a vacuum. You have got to make sure that you  
19 have got everything off there.

20 STEINHAUER: Any other comments?

21 BREDENNER: To clarify that, it is the water vapor  
22 in your molybdenum type firing that combined with carbon  
23 produce carbon dioxide and hydrogen which removes the organics  
24 but you don't get this in vacuum obviously.

25 RUBIN: This is a question I ought to direct toward

1 Ceramaseal Manufacturers. Does this air firing cause  
2 migration of any glassy phases within the body? How is the  
3 glaze affected during this air firing? And does it penetrate  
4 the body under these firing conditions?

5 BREDBFNNER: The softening phase in these ceramics  
6 that are specified, the glassy phase, that is, is up around  
7 1400 centigrade, so obviously you are not going to get any  
8 glass migration.

9 What was the other question? Oh, the affecting of  
10 the glaze. In my specification that I submitted was that the  
11 glaze -- one of the requirements is that the glaze must be  
12 able to take 100 degrees centigrade in a vacuum at 10 to the  
13 minus 4 without chemical or -- let me find it here -- must  
14 exhibit thermal and chemical stability in vacuum 10 to the  
15 minus 4 at temperature of 1000 C.

16 STEINHAEUER: I would like to comment on the need  
17 for air firing even in the molybdenum process. We found  
18 in vacuum tube industry to be extremely critical. It is  
19 highly desirable.

20 Comment on 4.2. We do not have a ball mill process.  
21 Particle size is certified by the vendor from whom we purchase  
22 the active metal material. The certification should satisfy  
23 the intent of the specification.

24 BREDBFNNER: I would like to make some changes in  
25 4.2.1, .2 and .3 there. I agree with the comment that you

1 made. What I would do is specify a powder of, in my own  
2 case, 99 percent minimum purity titanium, ballmill another  
3 powder if it will not stay in suspension without constant  
4 stirring after mixing with organic suspension vehicle.

5 Now, this was written to constantly stir it and I  
6 think we ought to have a mix that doesn't need that.

7 Another point here is that we are using a one-  
8 component powder. We needn't worry about various -- for  
9 instance, if you had a two-component powder of 80-20 and you  
10 didn't keep the right distribution there you would obviously  
11 foul up your metalizing. One-component powder, you can only  
12 put it on one component. So the worry here is unwarranted.

13 I think the ball milling should specify the things  
14 that are stated here and I specify a \_\_\_\_\_ also.

15 UBANKS: Shouldn't we also specify a particle size  
16 like less than 7 microns or something like that rather than  
17 say particle size and size distribution should be --

18 BRFDDBFNNER: Up to recently we bought a 300 mesh  
19 powder and it always was fine without any ball milling.  
20 Recently this company stopped making the powder and we have  
21 had to resort to ball milling in most cases. We are still  
22 buying the same mesh powder, but most of the time it needs  
23 ball milling.

24 Certainly there is a certain size here that you  
25 need, or a size distribution that you need, but after the ball

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1 milling and a specified time and doing it properly and then  
2 putting the powder in a mix, I think that is a good enough  
3 test to determine whether it is going to stay there.

4 STEINHAEUER: Further comment on that. In moly-  
5 manganese the particle size was important, but even more  
6 important seemed to be the particle size distribution. It  
7 could get drastically different results unless you reproduce  
8 that distribution.

9 I have a comment on 4.2. Active metal is a term  
10 usually applied to titanium zirconium hydride which is used  
11 in ceramic metal seal processes but is different from the  
12 sintered metal powder process, commonly called moly manganese  
13 but which includes moly manganese and a number of other metals.  
14 Use of the term active metal may be confusing unless you mean  
15 to say that only active metal processes will be used in the  
16 seal manufacturing which I don't think you do.

17 No, it is not the intent to exclude this. There  
18 is some concern on the attack by koh of a moly manganese metal-  
19 izer. If you can protect this -- this would be of concern  
20 if there is data to show the seal to be adequate.

21 CARR: We are currently working with a different  
22 vendor on a new metalizer so I would recommend that in writing  
23 the specification that you put down what you want in the  
24 matter of controls rather than discussing the, you know, the  
25 two processes we are talking about. In other words, what we

1 are trying to say is well, we want to use bone-tip tweezers  
2 so we don't put any metal on it. I think we ought to say we  
3 don't want any metal on it.

4 STEINHAEUER: Okay. We have no comments on 4.2.1.  
5 On 4.2.2 I have a comment. The Mill winner and ball composition  
6 should be high alumina composition to avoid contamination of  
7 the metalizing mixture.

8 Any comments on that, or other comments?

9 (No response.)

10 STEINHAEUER: Okay. No comments on 4.2.3.

11 4.2.4., standards should be set for green metalizing  
12 thickness. I think that is fairly standard as a control.

13 Okay. I don't have comments until 4.4.3. Anything  
14 between 4.2.4 and 4.4.3?

15 BILGERBECK: 4.3.1 here, I believe, Bob. Test  
16 should be on actual design configuration, referring to tensile  
17 test.

18 STEINHAEUER: We have some comments that we have  
19 been asked not to include here for the moment.

20 BILGERBECK: Okay.

21 STEINHAEUER: Paragraph 4.4.3. We question the  
22 validity of a braze flag test on an alloy whose contents are  
23 certified.

24 Any comments on that?

25 (No response.)



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1 STEINHAEUER: Well, then, I would like to comment.

2 In dealing with a great variety of braze materials,  
3 and there are only a limited number of sources for these  
4 precious metal alloys in this country, where we were perform-  
5 ing hundreds of spectrographic analyses a week in a vacuum  
6 tube operation, we found that it was not an infrequent  
7 occurrence that the alloy you got was not the alloy you  
8 ordered.

9 A certified analysis doesn't mean a whole lot  
10 here and the braze flag test and a lot spec analysis seem  
11 to be minimum to control that.

12 On 4 -- I have a comment on 4.5.2.2. Is there  
13 anything that anyone would like to say between 4.4.3 and  
14 4.5.2.2?

15 (No response.)

16 STEINHAEUER: 4.5.2.2. It says this test is  
17 redundant as pinch tube-cover welds are inspected as part  
18 of the general cover inspection.

19 HALPERT: I think it was mentioned by someone  
20 before in this area 4.5 is where we should possibly spell  
21 out the alloy used in cover assembly, whether it be 304, 303  
22 or what.

23 STEINHAEUER: Yes. I think this is important,  
24 particularly on this cover and particularly where you are  
25 making a braze to that cover.

1 Mel, would you have any comment on 304L versus  
2 304 or other stainless materials where you are going to be  
3 contacting a braze material?

4 BREDBENNER: I think 304L for higher reliability.  
5 I think 304L having a low carbon and never having to worry  
6 about carbide precipitation is important, it is possible in  
7 some of these welds that there could be a point for corrosion  
8 here.

9 303 was mentioned earlier. It has sulfur in it.  
10 It is no good for welding. There is a 303MA material  
11 recently developed that is supposed to be weldable. Nickel  
12 is probably the best material as far as not getting into  
13 trouble.

14 STEINHAEUER: Yes. I would agree with that  
15 particularly where braze alloy is in contact with the material.

16 RICHARDSON: On 4.5.2.1, talking about 100 percent  
17 inspection there for the cracks, porosity and this type of  
18 thing; you are talking about the weld on the pinch tube in  
19 this area? On this 4.5.2.1, are you talking about the weld  
20 to cover the can or cover the case?

21 STEINHAEUER: This was on the cover assembly, so I  
22 am quite sure we are referring to the pinch tube.

23 RICHARDSON: Okay. There you get into a problem  
24 when you are talking about porosity. You get a lot of  
25 porosity that is below in the welded area and you are talking

1 about inspection, you are not going to see it, not unless you  
2 x-ray it. And there is also the possibility of internal  
3 cracks, and here again -- here you say inspection. What do  
4 you mean, are you talking of visual inspection or radiographic  
5 or what? You say 100 percent. It is not clearly defined  
6 there.

7 STEINHAUER: The items that are called out would  
8 indicate a visual inspection, and I would agree it is  
9 probably not adequate.

10 RICHARDSON: We ought to say maybe a visual -- if  
11 you do say visual you probably won't see any cracks with a  
12 visual or anything like that.

13 STEINHAUER: If it is a weld this is true. Visual  
14 is very useful if it is a brazed pinch tube to the cover,  
15 as far as the filleting and so forth.

16 RICHARDSON: You know, it is a pretty small area  
17 actually and cracks and welds, we have seen cracks at Marshall  
18 under x-ray and they are small minute cracks that you can't  
19 see with a visual inspection whatsoever, even after looking  
20 at them under magnification occasionally. We actually view  
21 x-rays under magnification. But here again, we are working  
22 with high pressure type of welds and a structure that you  
23 are requiring to take high pressures and vibration and various  
24 harsh environments, whereas this, there could be some high  
25 pressures involved, but --

1           STEINHAUER: Recognize that in a welded assembly  
2 this would be true. In a brazed assembly x-ray may not be  
3 an applicable technique. It is very difficult in a ductile  
4 alloy.

5           RICHARDSON: Then you get to the point if you x-ray  
6 what is acceptable and what is not acceptable. And you can  
7 get all kinds -- you get into problems there also.

8           STEINHAUER: Great.

9           GROSS: I agree with the speaker. We have tested  
10 by x-ray a number of seals and in all cases been able to  
11 detect some defects.

12           I would like to add a general -- I would like to  
13 see a statement added in the specification which gives  
14 preference to seal designs that can be inspected by x-rays.  
15 Most of the seals now manufactured can be inspected by  
16 x-rays, but it is extremely tedious and a difficult operation.

17           STEINHAUER: On 4.5.2.3, cover assembly lot is  
18 undefined. This is one sample per lot. We haven't specified  
19 a sample size and this, of course, is going to depend on an  
20 individual manufacturer's process, the number that actually  
21 goes through in a batch assembly.

22           Any comments on that?

23           GASTON: I have a comment on 4.5.2.1. I believe  
24 that you also inspect for weld splatter which occasionally  
25 occurs and probably could eventually fall into the cell.

1 STEINHAUER: If it is on the underside.

2 GASTON: If it is on the inside.

3 STEINHAUFER: Yes.

4 SCOTT: With regard to 4.5.2.3, I think this is  
5 one of a number of cases where possibly the final wording  
6 maybe should be referred to the MIL Standard 105D or other  
7 applicable sampling plans and not just numbers picked  
8 arbitrarily out of a hat. I think maybe we need to go through  
9 this thing in a number of cases and actually look at what  
10 is available and what is being accepted in terms of  
11 statistically valid sampling plans and work those into the  
12 spec.

13 STEINHAUER: Yes, I agree. The question is,  
14 though, that each manufacturer puts through a certain lot  
15 size of parts through their process and the variables that  
16 you get within that batch may not be the same as the next  
17 batch and I think the original intent of this was one sample  
18 per manufacturing batch to know that the furnace or the  
19 vacuum braze was in control for that lot.

20 It would be nice if this was a continuous process  
21 and it would definitely lend itself to statistical sampling.

22 EREDBENNER: One thing that is omitted in this  
23 group is spot welding and the quality thereof.

24 STEINHAUER: Of the negative terminals or where in  
25 particular?

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1 BREDBENNER: Well, there is either a comb or a lug  
2 there on one side and a lug on the outside of the can.

3 STEINHAUER: True.

4 RICHARDSON: Also your third electrode there also  
5 spot welding it is a possibility. You have a tab attached  
6 to the third electrode which attaches to the cover.

7 STEINHAUER: Yes.

8 FORD: I might point out it is probably already  
9 obvious to many of you that the spec deals with a standard  
10 aerospace type cell. There is no attention addressed to  
11 the third electrode cell in the spec. However, it will be  
12 a natural fallout that after this spec is finalized the third  
13 electrode requirements will be included as part of the final  
14 specification.

15 GROSS: With Ford's comment in mind it would seem  
16 reasonable to make sure that the format and the paragraph  
17 number assignments have adequate room for new things that are  
18 going to be added at a later time so that they will fit in  
19 in a logical manner.

20 STEINHAUER: Okay. On 4.5.3.2 it is recommended  
21 the use of dual thermocouple one monitor at the bottom at  
22 the end of the load zone and one control at the center of the  
23 load zone. Chart recorded.

24 This is a matter of process control on the furnace  
25 or on the equipment.

1           The next comment we have is on 4.5.2. Are there  
2 any comments between 3.2 and 4.2?

3           (No response.)

4           On 4.2. Why does the customer need this type of  
5 information, especially since the end product undergoes such  
6 rigid testing?

7           This is in reference to the recording of the braze  
8 time and temperature cycle.

9           UPANKS: Well, it may not be necessary for the  
10 customer to really know these numbers, but as a matter of  
11 process control I think they should be recorded, and of course  
12 if the customer would like to look at these data books and  
13 so forth, if something goes wrong I see no reason why he  
14 shouldn't. But I do think that this information should be  
15 recorded as a matter of process control, braze time and  
16 temperature.

17           STEINHAUER: I definitely agree with that. It has  
18 been extremely useful to be able to go back in one case to  
19 complete lot traceability and find out each variable within  
20 the metal ceramic process of a lot that failed to see if there  
21 was any correlation. It turned out not to be, but it was  
22 extremely useful to have that information.

23           4.5.4.6.

24           RICHARDSON: Back on this 4.5.4.3, you say visual  
25 inspection using magnification where required. This could

1 give you a problem because if you don't spell out magnifica-  
2 tion one inspector is going to use a 5X, you know, and the  
3 next guy down the line will use a 50X and he rejects the whole  
4 damn bunch because he sees something under there that you don't  
5 see under the 5X, so if you are going to say use magnification  
6 you ought to spell out 5X, 10X or else say visual period  
7 assuming now allowing any magnification.

8 STEINHAEUP: Agreed. It is common to use 10X in  
9 the vacuum tube industry. I would make that as a suggestion.

10 RICHARDSON: It ought to be spelled out.

11 STEINHAUEP: Agreed.

12 Anything on 4.4, 4.5? Insulation resistance, leak  
13 check, 100 percent?

14 (No response.)

15 STEINHAUER: On 4.5.4.6, 5 percent random sample is  
16 considered excessive. This is on braze quality metallurgical  
17 sectioning.

18 Everybody agrees? Five percent is all right.

19 HALPERT: Five percent of what?

20 STEINHAUER: Of the number of parts.

21 HALPERT: I think that you have to spell out what  
22 the sample is and determine how many you are going to check  
23 from there, how much is a batch. That will tell you what  
24 the random sample should be, especially if you are going to  
25 use a MJL-STD-105 which will tell you how many you could then



1 look at. So 5 percent could be a lot or it could be a little.

2 BELOVE: The procedures specified sample size based

3 on a percentage of a lot is a poor way of selecting a sample.

4 STEINHAUER: I think what we have to do is define

5 a manufacturing lot from a sampling or statistical standpoint.

6 Yes, we should specify a MIL standard procedure, but each

7 person making metal ceramics has a different manufacturing

8 lot size, and is this sampling procedure through different

9 manufacturing lots applicable?

10 BREDENNER: It is impossible to apply MIL-STD-105D

11 on destructive testing. If you have a lot size of 10 you

12 will bust almost every one of them. You have got to somewhere

13 when you are doing destructive testing use a percentage figure.

14 When it gets into real small lots, obviously you don't get

15 enough, but you should do at least one or two. So you can

16 set a minimum number based on say you are doing 25 pieces you

17 would wreck one or say we will break one out of every 25 or

18 not to exceed 5 percent of the total lot.

19 STEINHAUER: Yes, Jerry?

20 HALPERT: Would you expand on your statement? Were

21 you talking about only the ceilings now or about all samples?

22 Would you expand on what you mean?

23 BELOVE: I was paraphrasing what you were saying

24 before about the MIL spec is based upon the fact that in order

25 to get a decision based on a number of rejects that describe

1 the level at which you will accept and reject, that in turn  
2 works back to tell you what an average sample number should be  
3 And specifying the percentage doesn't perform that task. In  
4 fact, it works against you.

5 STEINHAFER: Comment on 4.5.4.6, destructive peel  
6 test to see entire bond area and adequacy of bond.

7 I believe that was a Ceramaseal comment. I take  
8 it that is a recommendation? Destructive peel test to see  
9 entire bond area and adequacy of bond.

10 BREDBENNER: The reason for that was the fact a  
11 metallurgical section only sees -- you only see a small part  
12 of the seal. Ceramic to metal seal is commonly the best way  
13 to check them is to peel them. You get a feel for the  
14 strength as well as you see the entire bond area.

15 STEINHAFER: And your concern was whether you pull  
16 ceramic or -- okay.

17 HALPFERT: Is that a standard test?

18 BREDBENNER: Yes.

19 STEINHAUER: Are there any further comments in  
20 this section?

21 (No response.) ,

22 STEINHAUER: I believe Mel Bredbenner requested to  
23 comment in general on metal ceramics. Mel? No? Okay.

24 MAURFP: I have a comment. I think we should  
25 consider another test on some sample of the lot which includes

1 thermal cycling of the seal, perhaps in a dummy cell configura-  
2 tion with voltage applied. This has a tendency to accelerate  
3 leakage of potassium hydroxide along certain elements in the  
4 seal, say minus 48 degrees centigrade to plus 160 degrees --  
5 sorry, Fahrenheit -- one hour each for 40 or 50 cycles.

6 STEINHAUER: As a shock test between the two  
7 temperatures?

8 MAUREP: Not really a shock test, no. Just a thermal  
9 cycle that allows sufficient time to not induce great strains  
10 in the seal. I am not thinking of the thermal shock so much  
11 as just flexing it.

12 STEINHAUER: Yes.

13 MAURER: And this induces weak points to break and  
14 leakage to be induced.

15 PAMPFL: I think along those lines that should be a  
16 qualification item on the seal when first designed because if  
17 you are going to bring that sort of thing in you also have  
18 to take the ceramic material and boil it in KOH for a few  
19 months and measure the rate loss and do catodic and anodic(?)  
20 oxidations and so on and so forth and I just assume that this  
21 was done in the beginning when the seal was designed and  
22 qualified.

23 SCOTT: I tend to agree that the type of test  
24 indicated by the numbers for the thermal cycling and all don't  
25 appear to me to be suitable for in-process control testing.

jon59

1 They are more of a qualification nature.

2 BPFDBNNER: It is common to call out a requirement  
3 that this assembly must take thermal cycle from such to such  
4 under certain conditions, yet not required as a production  
5 test. It can always give you something to fall back on if they  
6 don't pass.

7 Maybe I shouldn't have said that.

8 (Laughter.)

9 GROSS: The thermal cycling test is nevertheless  
10 very useful for determining if in a general sense how good the  
11 cell seal is and it would be useful in picking up any long  
12 term changes in a particular design. So an occasional cell  
13 seal tested in this way would give you an idea of how that  
14 particular seal has changed over the years.

15 STEINFAUFR: I would like to comment here. I am  
16 strongly in agreement on thermal cycling, but recognize that  
17 the metal ceramic or any seal that goes through a furnace or  
18 vacuum braze operation gets a pretty severe thermal test after  
19 that braze solidifies. But still, thermal cycling, we use  
20 that intensively ourselves, both in military and space  
21 applications.

22 Yes?

23 MAURFR: I was going to say that some ceramic seals  
24 will fail this test in one cycle. Some plastic seals will  
25 fail it in a few cycles. And a well designed plastic seal

1 will last for 2000 or 3000 cycles. The longest ceramic  
2 seal that I have had experience with was about 40 cycles.

3 Now, if you have an automatic -- a programmable  
4 oven, cold chamber, these cycles can be carried out, 40 cycles  
5 in roughly a week's time with no trouble at all. So we are  
6 talking about a week's worth of work, not months of work.

7 STEINHAUER: Anything further?

8 RICHARDSON: Talking about minus 40, you said plus  
9 what, plus 160 or something like this?

10 MAURER: What temperatures you are operating your  
11 batteries at. Our batteries are hopefully operated in a  
12 fairly nominal range above -- around zero degrees C to maybe  
13 plus 30, so really we are not going to see a tremendous amount  
14 of thermal shock on these seals. So normally if you are  
15 testing to these lower range limits and higher range limits  
16 it is normally in that area when you get to exceeding these --  
17 if you were to run acceptance tests on seals you would want  
18 to maybe run them in a range that your batteries were going  
19 to see. If you are going to operate them from zero to plus  
20 40 C, maybe that is the range you possibly might want.

21 MAURER: I agree we want to modify these numbers  
22 based on your use mode. In the Bell system we see temperature  
23 variations of this type. However, you want your test to  
24 exceed the limits of your application so you have some margin  
25 of error in the ceiling. You might not want to go to the

1 extremes that I mentioned, though.

2 BREDBENNER: I think the real thing that causes  
3 these seals to fail is not temperature, but pressure that  
4 builds up inside. Just simple thermal cycling wouldn't do  
5 anything. We do it on everything minus 50 to plus 150 C.  
6 But I think it's the pressure buildup on the high temperature  
7 side that causes the seal to actually fail, and this involves  
8 getting a strength value on the design as such, on a push out  
9 of the seal, to see what it takes.

10 MAURER: Isn't there a flexing in the seal area  
11 that occurs during a thermal cycle, and would this not tend  
12 to cause fatigue in a bond that's not as good as it might be?

13 BREDBENNER: The seal as designed is under com-  
14 pression, and any heat you put to it begins to relieve that  
15 stress that's already on it, until you go above a certain  
16 point -- which is above 450 C., usually.

17 In the range we're working in, we're actually  
18 relieving the seal. In addition, in the flange area, there's  
19 a built-in flexing, relieving the pressure on the seal area.

20 STEINHAUER: I would like to comment on something  
21 that I forgot to say before on 4.3.1. The original intent --  
22 I think this was a typographical error -- was to have the  
23 sample tensile strength must exceed 6,000 psi, which is not  
24 an unusual number for any of these processes, rather than  
25 600.

1 Further, on this question of pressure that has been  
2 brought up, we have tested the ceramiseal seal by taking a  
3 nicad cell and pressurizing with nitrogen gas. The yield  
4 point, when the ceramic started lifting and the stress relief  
5 collar bending over was between three and four thousand psi.  
6 This is what the cell major walls restrained.

7 So the small pressures that we typically see in  
8 orbit -- 75 to 100 psi, or more typically down around 30 psi,  
9 are really not excessive for these seals.

10 MAURER: I'm thinking of fatigue cracking.

11 STEINHAUER: Cycling -- yes.

12 Okay, I think that covers the general ceramic  
13 section.

14 HALPERT: Thanks, Bob. I want to remind you -- if  
15 you haven't signed the attendance list, that's important, not  
16 for attendance but to receive copies of the minutes of this  
17 meeting. So anyone who has not signed the sheet with their  
18 name and address, please come down to the front after the  
19 meeting and do so, so you'll be sure to receive that.

20 At this point I think the next section we go to is  
21 number 7. We're going to skip over three until tomorrow  
22 morning. The next section is number 7, "Production Processing  
23 of Electrode Assemblies." And for this part of the meeting  
24 I'll turn it over to Floyd Ford.

25 FORD: Could I have your attention, please? Okay.

1 We will get started with Chapter 7, "Production  
2 Processing of Electrode Assemblies."

3 I have one general comment from a particular manu-  
4 facturer that says:

5 "This chapter applies to a specific process and by  
6 its nature excludes all other processes."

7 I have no comment on paragraph 7.1.1. Is there any  
8 comment from the floor?

9 Paragraph 7.1.2 --

10 RYDER: Ryder, Gulton. I do have a comment on 7.1.1.

11 FORD: I beg your pardon, I found it. Comment:

12 "Is there a technical justification for the control  
13 of humidity in a formation facility?"

14 That is, pertaining to paragraph 7.1.1. Any further  
15 comment on this paragraph?

16 (No response.)

17 FORD: Paragraph 7.1.2 -- I'm sorry.

18 CARR: Carr, Eagle-Picher. Is there any justifica-  
19 tion for this tight of a temperature tolerance also?

20 FORD: Any other comment?

21 (Laughter.)

22 I hope, if we get through this section -- we've set  
23 a tentative time to adjourn, I believe about five o'clock, that  
24 we probably will have time to go back and discuss philosophy  
25 and rationale behind some of these statements.



1 The next comment I have is on 7.1.2. Comment:

2 "Inasmuch as the most rapid rate of carbonation takes  
3 place in the first hours of exposure to the atmosphere,  
4 it is recommended that the time permitted to store  
5 electrodes in this environment be reduced."

6 STEMMLE: Stemmler, Goddard Space Flight Center. I  
7 call into question that assumption. This past summer I did  
8 an experiment wherein I measured the rate of accumulation of  
9 carbonation in an open beaker of 30 percent KOH, and it seemed  
10 to be rather linear for six weeks. There was no rapid rise  
11 that I detected, at all.

12 At the end of three weeks, in an initially 7.2  
13 normal KOH, we had about 3 normal potassium carbonate.

14 FORD: Any other comments in regard to that para-  
15 graph?

16 BOGNER: Bogner, JPL. I think you should specify  
17 maybe the level of clean room grade, different levels of clean  
18 rooms.

19 FORD: Okay, thank you. Anyone else before we move  
20 on?

21 Paragraph 7.1.3; Comment:

22 "We presently use a polyamide or teflon sheet to  
23 isolate the stack from the can and a filler of similar  
24 material to prohibit the vertical movement of the stack  
25 within the can."

1 Another comment:

2 "In order to produce a cell, other items must be  
3 added in addition to the place separator and electrolyte;  
4 that is, terminals, combs, ceramics, braze materials,  
5 et cetera. I think that this paragraph would serve the  
6 purpose better if it put the requirement on the purchaser  
7 of the cells to designate the materials he did not wish  
8 to have in the cells rather than have the manufacturer,  
9 who has the ultimate responsibility for the cell, to  
10 have to seek permission for the materials which he has  
11 been using for some time."

12 Is there any additional comment from the floor?

13 GASTON; Gaston, Grumman. I think it is easier for  
14 a manufacturer to supply the material he uses than to specify  
15 what you don't want to use. It's a tremendous list.

16 FORD: Other comments? Okay. We'll move on to the  
17 next topic. 7.1.4. I don't have any general comments appli-  
18 cable until I get to paragraph 7.1.4.4. Is there anything that  
19 anyone would like to bring up, between those? Yes?

20 CORBETT: Corbett from Lockheed. I have a comment on  
21 7.1.4.1 and also on what you said about 7.1.3.

22 I think the danger in for former paragraph is that  
23 you specify alkali resistant, which doesn't mean too much  
24 as far as what the stuff might do to the cell. That is, you  
25 talk about perhaps the material, the resin itself, remains

1 intact and keeps its adhesion, but it may contribute impurities  
2 to the cell.

3 Also, in regard to the comment that you read on  
4 foreign materials, I think we certainly do want to exclude  
5 all materials except those specified. And I think we do want  
6 to require that approval be gotten for other materials. I  
7 think that's the whole point of the paragraph -- that you do  
8 want to eliminate anything that's really dangerous, and in  
9 general I think you ought to eliminate things that you don't  
10 know anything about.

11 So you don't have to know something about them to  
12 want to eliminate them, I guess.

13 FORD: I gather we're talking about a list of  
14 specified components that will go into a cell.

15 FLEISCHER: Have we defined alkali resistant in  
16 this specification? I bring this up because in my experience  
17 we had a customer to look into the encyclopedia and discovered  
18 that Tenite, the plastic made by Eastman Kodak, was alkali  
19 resistant. And he used it in a cell. It is not alkali resis-  
20 tant, and it caused us a lot of trouble until we discovered  
21 what he was doing.

22 So I think we're going to have to have a definition  
23 for it. We need to 30 percent KOH.

24 FORD: To answer your question, I'm looking under  
25 the definitions under paragraph 1.2.3. I do not see a

1 definition to describe that.

2 MAURER: I think you need to specify that the alkali  
3 will not leach material out of the material in question.

4 FORD: Is there any other comment before paragraph  
5 7.1.4.4? If not, I'll read the comments I have on that  
6 paragraph. Comment:

7 "Is there a technical justification for having a  
8 minimum soak time of 16 hours? If not, this limit leads  
9 to delays in processing."

10 Comments from the floor?

11 (No response.)

12 FORD: Paragraph 7.1.4.5. Comment:

13 FLEISCHER: Excuse me. Did he propose a minimum  
14 time of soaking for this?

15 FORD: No, would you like me to read the statement  
16 again?

17 FLEISCHER: Yes, please.

18 FORD: "Is there a technical justification for having  
19 a minimum soak time of 16 hours? If not, this limit leads to  
20 delays in processing."

21 FLEISCHER: Well the answer to that question is yes.  
22 There is a technical reason for this. We can take up hours  
23 in explaining it, but the answer to the question is there is.

24 (Laughter.)

25 FORD: Okay, we'll return to that if time permits.

1 Paragraph 7.1.4.5. Comment:

2 "It is our experience that stainless steel clips  
3 will corrode under the formation environment. Since  
4 pure nickel clips are not readily available, it is  
5 requested that this paragraph include nickel-plated clips."

6 UCHIYAMA: Uchiyama, JPL. On your last comment  
7 there, I believe that is referenced back earlier in 2.4.3.1.5,  
8 about the nickel-plated. I think that there's a little incon-  
9 sistency about the two parts, but it will work itself out.

10 FORD: Thank you.

11 The next comment I have is on paragraph 7.2.1.1.  
12 Is there any comment from the floor before that?

13 SULKES: Sulkes, U. S. Army Electronics Command.  
14 7.1.4.7, where you talk about bubbling out and replacement of  
15 deionized water. Do you propose that the same electrolyte  
16 will be used for multiple formation cycles, or fresh electro-  
17 lyte should be added -- or you should replace the electrolyte  
18 for every formation cycle?

19 FORD: I don't believe there is any mention made of  
20 replacing the electrolyte.

21 SULKES: Do you feel perhaps this would be a better  
22 way to do it?

23 FORD: Are you asking me for my opinion?

24 SULKES: Yes.

25 FORD: I think it would be desirable.

1 Any other comment before paragraph 7.2.1.1?

2 GASTON: Gaston, Grumman. Paragraph 7.1.4.6. I  
3 feel there should be some requirement how securely these  
4 plates are fastened together, should be added. Whether it is  
5 by connectors, there should be some minimum resistivity --  
6 either minimum resistivity value, or some specification of  
7 how tightly they should be connected.

8 FORD: Other comments? If not, we'll go on to the  
9 next comment that I have. Paragraph 7.2.1.1.

10 "Edge coating of plates should be allowed."

11 Comments from the floor?

12 GASTON: Gaston, Grumman. Edge coating could lead  
13 to problems. If it's allowed it has to be carefully consid-  
14 ered in the material used, and how well it adheres and how  
15 well it adheres later on.

16 I've seen a failure mode to edge coating.

17 FORD: Other comments?

18 REED: Reed, Battelle. 7.2.1, about coining plates.  
19 If we go back here to 2.1.1.1.9 we've already decided that the  
20 plaques should be coined prior to impregnation. So I wonder  
21 what is meant by this paragraph 7.2.1?

22 FORD: I would think there's a redundancy in the  
23 two paragraphs.

24 The next comment I have is on paragraph 7.2.2.3.

25 Does anyone from the floor have comments on paragraphs leading

1 up to that particular one?

2 CARR: Carr, Eagle-Picher. With regard to 7.2.2.2,  
3 I don't believe we can cover all contingencies for sample  
4 plates. I think it's like the color standards. I don't  
5 think you can set up standards by showing things like this.

6 I think this was attempted on soldering, and they  
7 found it very difficult to, by samples or pictures of solder  
8 joints, to show good and bad. There's always something that  
9 falls in between someplace.

10 FORD: Other comments?

11 (No response.)

12 Comment on 7.2.2.3:

13 "With previous sorting as recommended by us, the  
14 allowable rejection rate should be significantly reduced."

15 Second comment:

16 "Because of the stringency of this specification,  
17 it is expected that more than 10 percent of plates  
18 could be rejected. However, with sufficient 100 percent  
19 inspection, and all subsequent testing which follows,  
20 the customer should be assured that he does get a  
21 reliable product. We, therefore, take exception to  
22 this paragraph whereby total spirals can be rejected."

23 RICHARDSON; Richardson, Marshall. I notice you've  
24 put a flat 10 percent. Would it be better to use a MILSTANDARD  
25 105.D., depending on the total quantity of plates? Some

1 manufacturers might build 3,000 plates, or something -- a  
2 given lot, and another manufacturer may only build 100. And  
3 your MILSTANDARD would take care of your lot size, in lieu  
4 of a flat 10 percent across the board.

5 FORD: Okay.

6 CARR: Carr, Eagle-Picher. Again, I would like to  
7 recommend that an action such as material review board auth-  
8 ority be considered before indiscriminately throwing away  
9 lots of material.

10 HALPERT: It seems to me that if this material can  
11 be used, in fact, in a commercial cell, I don't see why they --  
12 they'd probably be good for commercial -- we just want to make  
13 sure they're high quality in terms of aerospace.

14 CARR: Eagle-Picher does not manufacture commercial  
15 cells.

16 (Laughter.)

17 FORD: Anyone else care to comment?

18 CORBETT: Corbett from Lockheed. This is not  
19 directly on the matter at hand, but since Earl has brought up  
20 the point of a material review board a couple of times, my  
21 experience with organizations of this type, and quality  
22 assurance organizations in general, is that what happens when  
23 you have a particular technical problem is that the guy from  
24 MRB or the guy from whatever QA organization it is, eventually  
25 comes to the battery guy or the solar array guy or whoever it



1 is and says, "What should I do? Should I reject it or should  
2 I buy it, or what?"

3 So these people are not technical specialists.  
4 They're just people who are paper shufflers, who are charged  
5 with the responsibility of handling a particular problem.

6 (Laughter.)

7 And I just don't think that that's really solving  
8 the problem, to give it to the MRB, you know. It's a way of  
9 buying off a bunch of plates that you might want to hold onto,  
10 but that's about it.

11 CARR: Carr of Eagle-Fischer. Bob, the purpose of  
12 MRB is not just to guy off material, but it's to very  
13 definitely assign a corrective action and the procedures  
14 you're going to follow from thence on.

15 But just because 10 percent of the plaques may have  
16 a let's say what actually may be a minor problem, doesn't  
17 mean -- and let's say that the lot can be screened 100  
18 percent -- and the other 90 percent does not, does not mean  
19 we should throw the plates away.

20 RICHARDSON: Richardson, Marshall. That 7.2.2.3  
21 there which says -- it refers to 7.2.2.4 -- and if you look  
22 through the a,b,c,d,e there, these are visual inspection types  
23 of things here. And really, what you're really talking about,  
24 to 100 percent, you want to inspect all plates. And in essence  
25 here, for the surface type defects and visual defects, that

1 you cited in 7.2.2.4; so here again, you're going to wind up  
2 with a batch of good plates and a batch of scrap plates,  
3 really. Because there isn't any -- in essence you don't have  
4 any MRB if you've got all these cracks and nicks in the edges.  
5 They're bad plates, and there probably wouldn't be any MRB  
6 to accept or reject the bad ones. But maybe you'd want to  
7 come up with a change in the process or something of this  
8 nature, to maybe why you're getting a lot of blisters, or why  
9 you're getting a lot of cracks, or something like this.

10 CARR: Carr, Eagle-Picher. Right, John, I agree.  
11 That's the purpose of MRB, is to assign a qualified team of  
12 engineering, production and quality personnel, to analyze  
13 what the problem really is.

14 RICHARDSON: Right, but in material review action  
15 there's always a "use as is" disposition as one of the altern-  
16 atives. And obviously it would not apply in a case of  
17 defective plates.

18 CARR: Right. But we're discussion this provision  
19 which says that if you've screened through the plates and  
20 you've got 10 percent of them that have got bad edges, it says  
21 throw them all away. And I disagree with that.

22 FORD: Okay, Earl. I think your point is taken.  
23 One comment I might make along these lines in regard to a  
24 material review board is that usually, or in most cases that I  
25 have been aware of, you're faced with a production schedule at

1 the same time as you're faced with a material review board.  
2 And I can tell you, they're not always compatible.

3 SCOTT: Scott from TRW. Floyd, I was just comparing  
4 that paragraph that we were talking about, 7.2.2.3, with  
5 paragraph 2.4.2.6, which establishes acceptance level on a  
6 lot basis for a spiral. And I don't know right now quite why  
7 we are still accepting -- we're still applying lot rejection  
8 criteria in section 7, having already done it in section 2.  
9 I think those may be not compatible. You may want to take a  
10 look at that.

11 FORD: Okay. Other comments before we move on to  
12 the next paragraph?

13 (No response.)

14 Paragraph 7.2.2.4. Comment:

15 "The following is recommended in place of this  
16 paragraph as being more realistic and practical:

17 '1.0 After completion of cutting plaques to plate  
18 size, or prior to assembly into a formation pack,  
19 a 100 percent inspection will be performed on  
20 positive and negative plates using the following  
21 criteria as a basis for rejection:

22 1. A crack in the sinter exceeding 1/2 inch in  
23 length on both sides of the plate will be cause  
24 for rejection.

25 2. A crack on either side of the plate exceeding

1 three inches in length and two inches in  
2 width will be cause for rejection.

3 (Laughter.)

4 VOICE: That doesn't make sense. It sounds like a --

5 FORD: Let me read that one again to make sure I  
6 didn't --

7 (Laughter.)

8 "2. A crack on either side of the plate exceeding  
9 three inches in length and two inches in width  
10 will be cause for rejection."

11 (Simultaneous conversation and laughter.)

12 FORD: All right. I'd like to read over all of  
13 these before I ask any comments, if I may.

14 "3. Intersecting cracks will be cause for rejection.

15 "4. Parallel cracks within the pitch of one hole  
16 pattern.

17 "5. A crack, regardless of size, that gives evidence  
18 of flaking will be cause for rejection.

19 "6. Rough edges, burrs and snags exceeding 0.001  
20 inch. This inspection will be made with nylon  
21 gloves to feel for pulls on the fibers of the  
22 gloves. Inspection will include the entire  
23 electrode surface.

24 "7. If pimples or blisters are 0.002 inches above  
25 the electrode surface or the sinter material

1 is breaking away from the grid, the plate  
2 will be rejected."

3 At any time while I'm reading this, if you want me  
4 to go back, please stop me at that point, and I'll re-read it.

5 "8. Tabs will be free of sinter material.

6 "9. Coining of edges will be a minimum of  
7 0.015 inch.

8 "10. Plates will be of uniform thickness over  
9 the entire surface area (plus or minus  
10 0.002 inches). A 10 percent random sample  
11 will be selected for thickness determina-  
12 tion. If all samples can meet this thick-  
13 ness requirement, then all plates are acc-  
14 eptable. If one or more plates from this  
15 sample cannot meet this thickness require-  
16 ment, then 100 percent inspection will be  
17 performed to eliminate plates which do not  
18 meet this requirement."

19 That concludes the comment. Now I'll open the floor  
20 for comments.

21 RICHARDSON: Richardson, Marshall. Let me ask one  
22 question here. Does any -- does this actually get measured,  
23 actually go on and measure each plate for 1 mil cracks, width,  
24 or anything? That's in 1 mil thick? On a 100 percent basis?  
A crack that's -- and also on the length, okay. Wait a minute,

1 there's rough edges and burrs, half a mil -- I don't know,  
2 I'm asking the question -- how do you measure this? I don't  
3 know of any -- this would be an extremely time-consuming  
4 process to me, to do this, on a 100 percent basis. I don't  
5 know how you could do it, without a lot of shadowgraph or  
6 something like this, inspecting them individually.

7 HERZLICH: Herzlich, Sonotone. My remarks are with  
8 regard to blisters. I believe that no blisters should be  
9 allowed.

10 GREEN: Green, Martin. I notice one thing in here,  
11 that in both the comment and in here, that we are attempting  
12 to do something real exotic here, in inspecting these, and  
13 now we're getting into the fact that we're depending on the  
14 human feel.

15 I think possibly that something could be done about  
16 that, into some method that eliminates the human element.  
17 This feeling with gloves, nylon gloves in particular, has not  
18 proven to be anything more than to tell you it's there. It  
19 doesn't tell you how much or why. And I think some other  
20 means should be thought of in the finalization of this, to  
21 come up with some good mechanical means.

22 FORD: Other comments from the floor regarding  
23 that paragraph?

24 (No response.)

25 The next paragraph, 7.3. As you are aware, it

1 alludes to two methods to be used for plate identification and  
2 cell serial numbering.

3 Okay, comment on paragraph 7.3:

4 "Method A results in excessive losses due to the  
5 fact that the formation pack must have the same number  
6 of plates as the cell, and a single plate rejection  
7 during formation necessitates the rejection of the  
8 remaining good plates; this is rejection by association."

9 Second comment:

10 "We use and recommend a method somewhat different  
11 from either of those proposed. The formation is conducted  
12 as outlined in 'B'; however, in assemblage the positive  
13 and negative cell stacks, the plates are selected accord-  
14 ing to weight and thickness in order to arrive at uniform  
15 stack assemblies. These assemblies then remain fixed for  
16 all the following tests."

17 Any comments from the floor?

18 CARR: Carr, Eagle-Picher. We don't form in any of  
19 these ways. We perform a formation step before we build our  
20 cells, but we do an added formation step in the cell itself.  
21 And we would like for this to be considered.

22 FORD: Other comments?

23 FLEISCHER: I didn't understand the last remark. You  
24 mean you do not have a formation of the plates before you  
25 assemble them in the final cell?

1 CARR: If you're talking about the balance of the  
2 positive capacity versus the negative capacity, this we set  
3 finally in the cell itself, rather than setting the balance  
4 of precharge or whatever you want to call it, the discharged  
5 negative capacity against the charged negative capacity, we  
6 do that in the cell itself.

7 We do a formation step before that, but it's merely,  
8 in essence, a cycle, rather than a formation as is used here  
9 in the specification.

10 FORD: Other questions?

11 SCOTT: Scott, TRW. In the comment that was read,  
12 there was a term -- the business about matching positives and  
13 negatives -- positive and negative plates by weight and thick-  
14 ness -- in order to arrive at a uniform stack assembly.

15 I don't know -- I'd like to know what uniformity --  
16 how the term "uniformity" is being used there. Are you  
17 talking about thickness, compression, capacity, or what?

18 FORD: I won't call out the specific people that  
19 made the comment. If they feel free to do so now, they may.  
20 If not, we'll pass the question on for later clarification.

21 SULKES: Sulkes, U. S. Army Electronics Command.  
22 In your Method B, where you form cell packs and then break  
23 them up, you do have end plates which do have different  
24 charges put into them, than the rest of the plates. These then  
25 are distributed in an uneven manner throughout the batteries



1 when these packs are broken up.

2 Would you feel that it would be advisable to have  
3 the end plates removed and discarded?

4 HERZLICH: Herzlich, Sonotone. We find that thick-  
5 ness and weight offers only very very poor correlation in  
6 terms of matching. And the successful methods that we suggest  
7 include a capacity test of each plate. And matching the plates  
8 according to their individual capacity.

9 FORD: I think this morning that the gentleman from  
10 Sonotone mentioned -- this is what you're talking about -- you  
11 prefer the 100 percent capacity measurement on every plate?

12 HERZLICH: On each plate.

13 FORD: On each plate.

14 HERZLICH: And then bring them together in a matched  
15 cell.

16 BELOVE: Belove, Sonotone. There's one other  
17 thought in this, along this line. And that is, many of us  
18 have seen and heard of the effect -- that nickel-cadmium cells  
19 and the plates of nickel-cadmium cells appear to have some  
20 sort of a memory. That is, they react in the future in part  
21 in accordance with how they've been treated in the past. In  
22 other words, they -- a variation in charging regimen or  
23 discharging regimen may alter their performance on future work.

24 We believe in this case, then, that all cells -- all  
25 plates should be tested and that Martin Sulkes, as he mentioned

1 before, the end plates, we believe that these plates are  
2 being tested differently than the others, and this is one of  
3 the reasons that we say all plates should be tested individ-  
4 ually, rather than in cell packs, where you do have end plates,  
5 that will be tested or subjected to a regimen that is slightly  
6 different than the internal plates. And this difference may  
7 turn up later in cell performance.

8           RAMPEL: Rample, General Electric. I'd like to  
9 clarify something that Martin Sulkes said before, about the  
10 end plates, also. And I feel that whether or not they should  
11 be discarded depends on the last discharge, the final dis-  
12 charge.

13           SULKES: Sulkes, U. S. Army Electronics Command.  
14 Basically, they don't necessarily have to be discharged, but  
15 the way method B is set up, they're allowed to be mixed in  
16 and you could end up with 4 or 5 of them in one battery. And  
17 since they do have a different characteristic, this could cause  
18 a problem and non-uniformity.

19           PREUSSE: Preusse, Gulton. I'd just like to offer  
20 something to confound some of these statements, but not offer  
21 any explanation for performance. We deliberately manufactured  
22 a cell with negative electrodes, wholly made of end plates in  
23 formation, and put them through the process with cells in  
24 which end plates were interspersed in the cells. And in our  
25 18 days of acceptance testing, in the process we found no

1 significant difference, statistically, at the capacity, over  
2 charge voltage or pressures in the cell at all.

3 That's for interest purposes.

4 FORD: Other comments? My next comment is on  
5 paragraph 7.4. Therefore, if anyone from the floor has any  
6 comments on method A and method B, it's open for discussion  
7 at this time.

8 I might comment that we are very interested in  
9 looking at the method where plate identity is established and  
10 maintained throughout the life of the cell. There appears to  
11 be some justification in maintaining traceability from day  
12 1 on the plate group all the way to the end of life performance.

13 Comment 7.4. Lou Belove:

14 "The testing of plates in formation packs is consid-  
15 ered to provide 'average' results. For space applica-  
16 tions, plates tested as individuals provide the basis  
17 for maximizing cell uniformity and overcharge capability."

18 And I believe you had a comment you wanted to make  
19 from the floor?

20 BELOVE: No, I'm passing up the comments because  
21 it would merely be redundant. It's been repeated and repeated.

22 FORD: Okay. The next comment I have is on paragraph  
23 7.4.2(d). Are there any comments before that, from the floor?

24 SULKES: Sulkes, U. S. Army Electronics Command.

One basic philosophy I think that perhaps should be brought up

1 is either you do individual plates, which certainly gives you  
2 a bigger advantage, or you might just as well build these  
3 packs right into the cells and do your work there.

4 Since you really end up with the same result, you  
5 save an awful lot of handling. And the cost, let's say, of  
6 putting it in the cases is not as much as all this extra  
7 work that you're going through here. You just might as well  
8 reject them in a cell, if they're bad.

9 CORBETT: Corbett from Lockheed. Floyd, I'd like  
10 to ask what you meant by 7.4.2.(b). I don't quite understand  
11 what that paragraph means there.

12 FORD: You want me to interpret that?

13 CORBETT: Yes.

14 FORD: I'll read that statement:

15 "The volume of KOH contained in the formation  
16 container shall be equal to or greater than the volume  
17 displaced by the cell pack."

18 In other words, you want sufficient KOH in the  
19 container -- you have twice the volume of the cell pack of  
20 KOH in the container.

21 CORBETT: So the volume of the tank really has to be  
22 twice as big as the total --

23 FORD: Right. Any other questions?

24 The comment on 7.4.2(g) -- I'm sorry -- 7.4.2(d):

25 "We are not sure that this is at all possible,

1 because of the proximity of formation cases, and the  
2 fact that some out-gassing may occur with the expected  
3 entrainment of electrolyte. I think the practicality of  
4 obtaining the required resistance must be demonstrated  
5 under practical conditions before this paragraph becomes  
6 a rigid part of the specification."

7 I'll read the other comments I have in regard to  
8 7.2.2. I have one on paragraph (g):

9 "The tolerance of plus or minus minutes does not  
10 have any technical justification. A tolerance of plus  
11 or minus one hour in a 24-hour charge would hardly be  
12 significant, and it would be difficult to justify reject-  
13 ing a formation because the overcharge ran for 24 hours  
14 plus three minutes. Although we recognize the need for  
15 tight controls, they must at the same time be reasonable.  
16 We would recommend that a percentage of time, that is,  
17 plus or minus 4 or 5 percent, be considered."

18 The next comment I have is on paragraph (h):

19 "It is requested that the tolerance be extended to  
20 plus or minus 2 percent, and that this figure is reason-  
21 able from both a practical and technical standpoint."

22 The next comment I have is on paragraph (i):

23 "Since Section (h) of this paragraph practically  
24 dictates individual power supplies if these supplies are  
in effect isolated from one another then the 2 meter

1 system is redundant. We therefore propose that in those  
2 cases where those individual isolated power supplies are  
3 used, 1 meter be considered sufficient."

4 That concludes my comments on paragraph 7.4.2(a)  
5 through (k). It's open to discussion from the floor.

6 MAURER: I'd like to say that we should put something  
7 in on how the voltage should be measured, and at what point;  
8 because of errors that can creep in because of the voltage  
9 drop in leads the voltage reading point should be as near to  
10 the cell plates as practicable.

11 FORD: Okay. I think we get into that in the next  
12 paragraph; however, I don't believe it specified -- that  
13 there's any reference made to lead drop, or exactly at what  
14 point the voltage should be picked up.

15 The next paragraph, 7.4. --

16 SULKES: Floyd, I've got one. Sulkes, U. S. Army  
17 Electronics Command. Basically, after you've gone through all  
18 this trouble and all this expense, you're using awfully  
19 sloppy meters and basically not taking the data -- where now  
20 it's getting to where you've put all this expense into it --  
21 in other words, 1/2 percent meters are not uncommon, and I  
22 think in all our Army specifications we use plus or minus 1/2  
23 percent meters. The same thing on the difference between two  
24 meters. Here again you shouldn't allow plus or minus two  
25 percent on the voltage, which is (j). It would appear that

1 actually this probably should be continuously recorded. And  
2 I think there is certainly equipment available nowadays that  
3 can do this fairly easily and inexpensively.

4 FORD: Other comments on that paragraph?

5 (No response.)

6 Paragraph 7.4.3. Comment:

7 "We take exception to this paragraph for a number  
8 of reasons:

9 (a) The method of resistive loading of the cells  
10 results in the continued discharge of the positive  
11 between 0.5 volt and 0.0 volt. Because of voltage regu-  
12 lation requirements, this positive capacity is unavailable  
13 to the cell user. At the same time, that this positive  
14 capacity is being reduced, available negative capacity  
15 is also being diminished and becomes unavailable in the  
16 ratio tests.

17 In the case of a 20 ampere-hour cell, we have found  
18 that we obtained approximately 28 ampere-hours positive  
19 capacity to the half volt end point, and an additional  
20 8 ampere-hours when we one ohm to 0.0 volts end point,  
21 and a total measure negative capacity of 42 ampere-hours.

22 When we compute the ratios if we base it on the  
23 resistive loading technique, we end up with a ratio of  
24 1.2 to 1. However, if we computed it by determining  
25 positive capacity to 0.5 volt we obtain a ratio of 1.5 to

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Again, since the positive capacity obtained between 0.5 volt and 0.0 volt is for all practical purposes unavailable to the cell user, it should not really be considered as a factor in determining the cell's performance.

(b) It has also been our experience that the -0.2 volt is arbitrary and does not necessarily represent the failure of the negative, therefore, we would request that this value be changed to -1.0 volt."

That's all the comments I have on that paragraph. It's open to discussion from the floor.

CORBETT: Is this the whole paragraph now?

FORD: Yes, we're now talking about paragraph 7.4.3 in general.

CORBETT: Okay. Corbett from Lockheed. I think paragraph (d) is kind of a sensitive one for me, because you're talking about a percentage of the manufacturer's rated ampere-hour capacity. And I think different manufacturers for different sized cells and for different projects have a different idea of how much excess capacity you have to built into these cells. And if there's anything that this kind of specification achieves, I would hope it would be a standardization of the capacity of the cell, and the active material that's in the cell, compared to the rated capacity of it.



BELOVE: Belove, Sonotone. I believe that in order to make this meaningful, the rates used for charge and discharge should approximate as much -- as closely as possible -- the actual -- and the voltage, incidentally, should approximate the end use as closely as possible; otherwise, I do not believe this is meaningful. It's an approximation, but it does not come close to what will actually be obtained in cell or battery usage. That goes for the -- for example, discharging down to .5 volts. Well, we have seen cases, and I think most have seen this, where some cells will last longer than others to any given voltage, however, a different voltage level.

Now, if you are interested in providing a family of cells in a battery, and thereby provide long battery life, you must then know the voltage as you go along, and it must be usable voltage.

RAMPEL: Rampel, General Electric. With reference to the negative/positive ratio to plus 1/2 volt, and comparing it to the negative/positive ratio at 0 volts, I would like to mention that one may obtain a low ratio at 0 volts, down to 0 volts, but we have to consider the fact that when one is charging a sealed cell at cold temperatures, such as 32 degrees F., the charge efficiency of the positive is close to 100 percent, and so that will be the true ratio down to those temperatures.

1           HERZLICH: Herzlich, Sonotone. We believe that the  
2 1.2 to 1.3 to 1 ratio is ill-advised, and would like to  
3 recommend 1.75 to 1 as a minimum.

4           FORD: May I clarify a point here? I don't think  
5 that's intended to be a ratio, if you're looking at paragraph  
6 (d). The ampere-hour capacity of the positive plates, as  
7 determined in paragraph (b) above, shall be a minimum of 1.2  
8 to a maximum of 1.3 times the manufacturer's rated ampere-hour  
9 capacity. Okay?

10          CORBETT: He's talking about paragraph (g), though.

11          FORD: Oh, I'm sorry.

12          CORBETT: Where it also said 1.3.

13          SULKES: Sulkes, U.S.A. ECOM. In (g), it's 1.3 plus  
14 or minus 0.5. Does that mean the ratio is from .8 to 1.8?

15          VOICE: No, that's .05.

16          SULKES: Oh, okay.

17          FORD: Let me point out one further thing. That  
18 you're not determining the total negative capacity in paragraph  
19 (g). You're determining the minimum acceptable capacity at  
20 that point. It may be in excess of that.

21          RUBIN: Rubin, from Texas Instruments. A question  
22 to the gentleman from Sonotone is why he thinks the negative to  
23 positive ratio should be that high? Is there any technical  
24 support for that? Has Sonotone ever looked to the effect of  
25 pore volume filling, or the effect of cadmium loading and plate

1 thickness? On the effects of over pressure?

2           There is quite a bit of data that I believe was  
3 published in the power sources conference when it was conduct-  
4 ed in 1967, that shows high electrolyte fill as well as high  
5 cadmium loading can effectively stifle oxygen recombination  
6 rate.

7           And also, a heavily loaded cadmium pore will tend  
8 to block and fade much more rapidly than a more lightly loaded  
9 one.

10           PREUSSE: Preusse from Gulton. I think that there  
11 is also a hypothesis that the oxygen recombination character-  
12 istics are based on the number of active nickelcytes, and not  
13 on the negative capacity available in a cell. And if there's  
14 any question, I wonder whether Dr. Seiger can expand on it --  
15 can substantiate it.

16           SEIGER; I think there are about five manufacturers  
17 of nickel-cadmium cells here, and each one uses their own  
18 method in obtaining characteristics. Some may want to use a  
19 ratio of 1.3 or thereabouts; others may want a larger ratio  
20 of 1.7 or greater.

21           All of these depend upon how they want to design  
22 the cell and what they want the cell to do. It also depends  
23 upon what the cell does as it ages. As well as the conditions--  
24 the rates, and the temperatures under which the cells are used.  
25 I believe if we went to volume III of last year's meeting --

1 the minutes of last year's meeting, you would see that we had  
2 this particular aspect brought up. As a matter of fact, it  
3 was Jim Dunlap who asked the question I had given a particular  
4 answer still holds.

5 I could give an answer of what I want, or how I  
6 want to design the aerospace cells that would perform. I'm  
7 sure that Ed Rubin has another answer for his plates; Rampel  
8 has another for his, and Herzlich another for his. And we  
9 want to consider all these things.

10 We're dealing with five different manufacturers --  
11 not with one spec, really. But what should come out of this  
12 is what is the best way that each one should make their plates.

13 FORD: Thank you.

14 RAMPOL: Rampel, General Electric. With regard to  
15 ratio in general, whether it be 1.2 or 1.3, the need for  
16 higher negative to positive ratios is really a necessity to  
17 provide varying degrees of precharging of the negative.

18 HALPERT: On that number 1.30 plus or minus 0.5,  
19 we're looking, as you said, for a minimum negative/positive  
20 ratio. Why would we want to -- and what you want to consider  
21 is why we need a plus or minus on it. If we want 1.3 that  
22 should be the minimum. We wouldn't want 1.3 plus or minus  
23 anything.

24 In other words, it can be plus anything, but the  
25 minimum should be 1.3 or 1.25, whichever is decided on.

1 FORD: I think, if you'll read it again, it's 1.3  
2 plus or minus .05 times the positive plate capacity. It just  
3 gives you a tolerance in multiplying your numbers out. But  
4 a minimum of 1.3 is what really is being asked for.

5 Other comments?

6 GROSS: The objective of the specification is to  
7 obtain long-life batteries; long-life I believe is ample test  
8 data that shows that long-life is promoted by operation at  
9 low temperatures. And so, therefore, we would like to operate  
10 batteries at low temperatures. At low temperatures, however,  
11 the negative plates have lower efficiency, and one would  
12 expect, therefore, to require a larger amount of negative  
13 plate material.

14 FORD: Other comments?

15 (No response.)

16 I see it's about four minutes after five. I think  
17 we're at a fairly good point to break. If there's no objection  
18 at this point from any of the other Committee members, I think  
19 we'll start off in the morning at nine o'clock at paragraph  
20 7.4.4, "Wash, Rinse, Drying Plates."

21 I'd like to thank you for attending today, and  
22 especially thank you for taking part in the meeting; because,  
23 after all, you're the people who are going to make this spec  
24 work.

25 (Whereupon, at 5:05 p.m., the meeting was adjourned,  
to reconvene at nine o'clock a.m., Friday, October 31, 1969.)

RJM

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CR9053

## NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Goddard Space Flight Center

## TECHNICAL/SCIENTIFIC MEETING

on

## SPACE BATTERY SPECIFICATIONS

Building Number 3  
Goddard Space Flight Center  
Greenbelt, Maryland

Thursday, 30 October 1969

P R O C E E D I N G S

HALPERT: I just have a couple of quick comments.

There were two briefcases left in here overnight, and they were taken out to the guard house and they have been returned. If you are missing a briefcase, you can claim it I guess come see me and I will see if I can find them. They're in the back of the room somewhere.

Second, if you haven't signed the roster, please make sure you do so to receive a copy of these comments of the meeting. If there is anybody who came in today who does not have a copy of the specifications, we have copies here which I will be glad to pass out to you. Is there anybody who does not have a copy of the specs this morning.

Okay, I guess we'll go back to number seven and Floyd Ford.

FORD: Good morning. Before I get started I would like to reiterate a point that was made yesterday. The purpose of the microphones that are being handed to you is to facilitate the recording of your voice, so that the reporter down here can use these tapes to fill in any place that may be void in his records. So, this morning when you want to make a comment just indicate by raising your hand, and the gentleman on the right or left aisle will hand you the microphone. And if it takes a couple of

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1 seconds to get it, we'll wait until you have the micro-  
2 phone in your hand. But it is really for everyone's bene-  
3 fit because I would like to know that everyone's comment  
4 does get recorded.

5 We are on paragraph 7.4.4.

6 Comment: From the point of view of carbonation,  
7 we recommend drying under vacuum rather than in circulating  
8 air for 24 hours. Are there any comments in regard to  
9 7.4.4?

10 FLEISCHER: I'd like to make a comment on that.  
11 I'm sort of surprised that the engineers will allow that  
12 commend to stand, because what you do in a vacuum is you  
13 have heat transfer problems, so that unless you have a  
14 circulating gas you're in troubles. And the equipment  
15 that you need will go way up in size.

16 So, you are trading off dollars here. It is much  
17 better if you have a circulating gas, and it would be  
18 better actually if you are worried about CO<sub>2</sub> to take it out.

19 FORD: The next comment I have in on paragraph  
20 7.4.4.2. Is there any comment leading up to that para-  
21 graph?

22 Comment on 7.4.4.2: We should like the techni-  
23 cal justification for the 55°C limit on drying of plates.  
24 That's all the comment. Are there comments from the floor  
25 on that paragraph?



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1 MAUREP: Do the negative plates at this time  
2 have a state of charge adjusted, and do we really want  
3 to dry charge negatives in air at 55°?  
4

5 FORD: According to the previous paragraphs  
6 the negatives may have some charge. I say "may." And  
7 most probably they will.

8 The next written comment I have is on paragraph  
9 7.4.6(a). Would anyone care to comment on paragraphs  
10 leading up to that paragraph?

11 Comment up to that paragraph, from the floor?

12 (No response.)

13 This is going to be a slow morning.

14 Comment: The applicable portions of MIL-W-8611  
15 should be defined. There are some provisions in that  
16 specification which are not at all practical. A comment in  
17 regard to (b) of that paragraph: We question the technical  
18 justification for the plus or minus .003 inches alignment  
19 tolerance.

20 Okay, are there comments from the floor?

21 FLEISCHER: I notice in some of these suggestions  
22 it says that in this one there is no justification, or  
23 what is the justification for one percent, but no suggestion  
24 was made as to what is considered to be a reasonable figure.  
25 And I don't see how the members of the panel who wrote  
this specification could have access to all of the information

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1 which decides on what a percentage figure should be, and I  
2 think the suggestion should be made we think that this  
3 tolerance should be five percent or seven percent or whatever  
4 is considered to be a reasonable manufacturing tolerance.

5 FORD: Other comments?

6 GASTON: Gaston, Grumman.

7 I would suggest than an alignment fixture be  
8 used so you would get a close enough tolerance or very  
9 close tolerance in the alignment of the plates.

10 FORD: One comment I might make even though this  
11 is not a third electrode spec, this tolerance of alignment  
12 of plates, particularly in certain types of third electrode  
13 designs is most critical to present shorting of the third  
14 electrode, which will be covered in a third electrode spec.

15 Okay, the next comment I have written is in  
16 paragraph 7.4.8. I would entertain comments between those.

17 RICHARDSON: Rick Richardson, Marshall.

18 In 747 I would recommend you add a similar paragraph as  
19 you have in (d) in 746, "inspect for loose particles and  
20 materials when you're wrapping the plate stack." We have  
21 seen indications in the past where you get extraneous  
22 particles on the plates which become embedded and possibly  
23 after vibration or after considerable use you could get a  
24 short in there.

25 I think this ought to be 100 percent final inspection

rms 5

1 there, when you are wrapping the plates, inspect for any  
2 loose particles or extraneous material.

3 FORD: Would you care to comment on what type of  
4 particles you are referring to?

5 RICHARDSON: Pieces of silver. We've seen silver  
6 solder, occasionally, expulsion particles from weld tabs  
7 from the third electrode to a tab that would get embedded in  
8 the separator, Okay?

9 FORD: Yes.

10 RUBIN: Rubin, TI.

11 If it is the intent of the spec to have the  
12 operations listed in 7.4.6 and 7.4.7 to be sequential  
13 operations, then I recommend that the manufacturer have the  
14 option to do these in their own order of operation since  
15 there are advantages to wrapping a plate stack with a  
16 separator prior to welding. For example, bending of tabs  
17 back and forth, this also does disturb the alignment.

18 One comment on the alignment, plus or minus  
19 5000ths is probably a better number.

20 FORD: Would you bring the microphone down here.  
21 We have a comment in the front.

22 GASTON: Gaston, Grumman.

23 I would like to give an additional comment to the  
24 gentleman from Huntsville. I agree, yes, particles can be  
25 found and we have found nickel particles in the separator

rms 6

1 embedded. And the inspection for loose particles is very  
2 important. And it is a possible failure mode.

3 FORD: I guess I'm kind of curious on whether  
4 particles are in the separator to start with or whether  
5 they are coming from the handling of the separator, et cetera.

6 RICHARDSON: Richardson, Marshall.

7 Here again maybe some of the battery manu-  
8 facturers may elect to wrap the plate stack first prior to  
9 welding the combs of the tabs, and here again you'd want to  
10 provide some protection of the plate stack on top of it  
11 in case you got anyexpulsion particles again when you're  
12 welding plate tabs in the comb.

13 And what was that other question of yours now.

14 FORD: I was just curious as to where the problem  
15 with particles in the separator is identified with  
16 particles in the separator before it is ever used or  
17 actually in using it to put it in the cell, these particles  
18 got into the separator.

19 RICHARDSON: No, they were not embedded in the  
20 separator. In other words, they were relatively large  
21 particles that would be extraneous to the separator. They  
22 are not really small -- in other words, embedded in the  
23 Pellon or something like that?

24 FORD: Yes.

25 RICHARDSON: No. To my knowledge we haven't found

1 anything like that, small particles embedded in the Pellon.  
2 I guess it is possible you could find something in there.

3 FORD: Other comments before we get to  
4 paragraph 7.4.8? Last call.

5 (No response.)

6 Comment regarding paragraph 7.4.8: We take  
7 exception to that section of that paragraph that calls for  
8 a total rejection with no retest allowable. It is possible  
9 for cells to fail the short test because of moisture, and  
10 it is therefore common to allow at least for air or vacuum  
11 drying of the stack.

12 If in fact the cells fail because of faulty  
13 separator, we see no reason why the cell should not be  
14 rewrapped and then retested. We see no problem generated  
15 by rework at this point.

16 Comments are open for the floor.

17 MAURER: If the short occurred because of a very  
18 fine particle in one of the plates poking through the  
19 separator, a rewrap may fortuitously avoid that short the  
20 second time, and it would reappear after a slight amount of  
21 shock and vibration. So, I would vote for leaving that  
22 rejection in.

23 GASTON: Gaston, Grumman.

24 In the present OAO cell specification we permit  
25 one rework cycle, so permitting one rewrap providing records

rms 7

rms 8

1 are kept, but a maximum of one rework cycle.

2 FLEISCHER: Reference was made in the objection  
3 that there was moisture present, and it isn't clear where  
4 the moisture comes from.

5 Number two is that some of the manufacturers just  
6 said that they wrap first and then do their welding and  
7 this would show up I take it after the welding.

8 FORD: Yes.

9 FLEISCHER: So, now, you are going to rework  
10 this group, spreading the plates apart.

11 FORD: Yes, that's sort of the question. And  
12 the comment does not allude to that, or no one else had  
13 made a comment in regards to if you have the tabs welded up  
14 then the concern I think would be in the flexing of the  
15 tabs to some extent to reweave the separator. And in some  
16 cases though this test may be run before the weld is made  
17 in which case a rework would be practical.

18 FLEISCHER: Well, I just wanted to bring out  
19 these points that the procedure may have something to do  
20 with what is allowable and what is not.

21 FORD: Other comments from the floor?

22 SCOTT: Scott from TRW.

23 I suggest that maybe this requirement of a  
24 hundred megohms resistance be looked at and possibly  
25 adjusted to resolve the difference between the effective

rms 9

1 moisture and the effective other shorting particles. I  
2 suspect that a reasonable value could be much lower  
3 resistance than that. So, I think that resistance require-  
4 ment there should be looked at before this thing is re-  
5 solved.

6 FORD: Other comments?

7 SULKES: Sulkes, U.S. Army Electronics Command.

8 There is no provision here that says they can't  
9 run a precheck of this very test before welding is made  
10 which in effect would allow a rework. In other words,  
11 they can do it before if they want to.. The other thing, I  
12 believe you do specify certain humidity limits which  
13 probably would hold you to this value and you shouldn't have  
14 that problem,

15 Since you know what the test is your manufacturing  
16 procedure should be set so that you don't run into problems  
17 with it.

18 FORD: Other comments?

19 SCOTT: One more. I don't feel that we know enough  
20 about the absolute value of completely dry separators at  
21 this point. And if some degree of moisture in the separator  
22 is no problem and that degree of moisture gives less than  
23 100 megohms, I think we're on the wrong track. Just the  
24 fact that the separator has some water content isn't necessarily  
25 bad at this point.

1 FORD: Anyone else?

rms 10 2 FLEISCHER: Your remark about the resistance of  
3 the separator, as I recall, if you take a sheet of cello-  
4 phane which has been preserved properly under the right  
5 humidity and temperature controls that are recommended by  
6 duPont and you measure the resistance Megger, you get up  
7 to infinite resistance, so that the separator shouldn't  
8 be a problem here in determining this.

9 I think your 100 megohms is a suitable figure.  
10 I could have been infinity.

11 FORD: I might point out that we also are talking  
12 about Pellon or the woven -- nonwoven(?) Nylon. You  
13 mentioned cellophane --

14 FLEISCHER: Well, that's the one I had measured.

15 FORD: Okay.

16 HALPERT: These plates are put together --  
17 prepared to put together in the cell -- they are clamped  
18 together in such a manner as to fit into the can or slide  
19 into the can properly. And if you have a plus or minus  
20 2 mil -- what we're asking for is plus or minus 1 mil --  
21 but even that's a 20 mil variation. If you have to squeeze  
22 the plates by that difference in 20 mils, you can get  
23 almost any resistance variation between the -- even in a  
24 Megger reading. It is not infinity. And it varies all over  
25 the lot I would say.



rms 11

1 FLEISCHER: You mean lower than a hundred meg-  
2 ohms?

3 HALPERT: It can go lower or greater. If  
4 there are no short problems, and if the separator does  
5 not -- I don't know what the effect of humidity is, but  
6 if there are no short problems, I would expect it to be  
7 greater than 100 megohms. So that number is a reasonable  
8 number, but I don't think it would be infinity, because  
9 of the fact that we're getting closer and closer, and you  
10 may really be close enough in terms of distance where there  
11 is maybe reasonable resistance. It's in the breakdown  
12 of the actual materials.

13 FLEISCHER: Well, I'm satisfied that a hundred  
14 is a reasonable figure.

15 FORD: Are there other comments?

16 GROSS: Gross, Boeing.

17 One of the important objectives of the specifi-  
18 cation is to obtain uniform, consistent processes by the  
19 manufacturers. I don't think that this is the time to  
20 include waivers in the specification.

21 When the manufacturer finds that something is  
22 wrong, not passing the short test, for example, then there  
23 is something wrong with the process. And this should happen  
24 once or twice and it should be straightened out. And it  
25 shouldn't happen again.

rms 12

1 FORD: I see no other hands, so I assume that's  
2 all the comments. So, we'll move on to paragraph 7.4.9.

3 Comment: A weight gain within plus or minus  
4 three percent appears to be high considering that the  
5 electrolyte can be filled to within plus or minus 0.1 cc.

6 I have no other comments until I get to para-  
7 graph 7.4.9.5.

8 MAURER: I have a comment. We haven't gotten the  
9 plate stack into the can yet at this point.

10 FORD: Okay. It apparently is out of place, but  
11 it applies in this paragraph. That is a good point.

12 NIETZEL: Nietzel, TI.

13 This is a specification and not a process outline,  
14 so I don't see any problem there.

15 SCOTT: Scott, TRW.

16 If indeed the provision for X-raying the cells  
17 after final assembly is to stand, which appears further  
18 down the line, it may be advisable to also X-ray at the  
19 point before the cover is welded onto the can in order that  
20 if any kind of rework is to be considered this is the time  
21 to do it on the basis of possible defects that might show  
22 up during the X-raying rather than after the can has been  
23 welded and shut.

24 I don't know exactly where that should come in  
25 here, because it isn't clear in going through the test

1 requirements here where the cover actually gets welded  
2 on.

3 FORD: Are there other comments?

4 REED: Reed, Battelle.

5 In paragraph 7.4.9.3 it calls for the use of an  
6 automatic buret to prevent contamination of KOH, I assume  
7 by CO<sub>2</sub>, all of the automatic burets that I know of are  
8 glass. And, of course, we know that glass and 30 percent  
9 KOH are not too compatible, so I would throw this out as  
10 sort of a general question. Does anyone know of a plastic  
11 automatic buret on the market?

12 NIETZEL: You can end up manufacturing one your-  
13 self, an automatic buret, stainless steel 304L, no problem  
14 at all.

15 REED: Do any of the manufacturers use such a  
16 device, or what sort of buret are they using to fill at  
17 the moment?

18 NIETZEL: Yes, TI does use such type of buret.

19 FORD: Other comments?

20 (No response.)

21 Okay, if not, we will move on to 7.4.9.5.

22 Comment: We see no technical justification for  
23 a three-minute limit after the filling operation. The same  
24 comment applies to the three-minute limit after the  
25 installation of the gage assembly. If there are some

rms 14

1 controlled experimental results we should be made aware  
2 of them.

3 The floor is open for comments.

4 (No response.)

5 Okay, the next comment I have is on 7.4.10.1(a).

6 The pressure of 0.0 plus or minus 2.0 psia  
7 appears to be an error.

8 Another comment in regard to paragraph 7.4.10.1:  
9 WE would like to know the technical justification of the  
10 one-hour limit after cell filling. The cell has already  
11 been gaged and evacuated. It is also mentioned in this  
12 paragraph that any indication of a leak is sufficient  
13 reason for cell being rejected. We suggest that this should  
14 read, "any confirmed leak."

15 Are there any comments in regard to that para-  
16 graph? That's all the written comments I have regarding  
17 chapter seven.

18 MAURER: I have a comment with respect to part  
19 (c) "Leak rate shall be less than  $10^{-5}$ ." All of the other  
20 tests of the sealed components were  $10^{-8}$ .

21 HERZLICH: I believe 7.4.10.1 (a) should be  
22 altered to read, "A minimum of 16 hours shall elapse between  
23 the filling operation and the beginning of the first  
24 charge on the cell." The word "beginning" is not in the  
25 present text.

rms 15

1 CARR: Carr of Eagle-Picher.

2 With reference to Dr. Maurer's comment regarding  
3 leak rate, we use the figure  $10^{-7}$  as acceptance criteria.  
4 But normally we find that the cells pass  $10^{-10}$ .

5 RUBIN: Rubin, TI.

6 I question the necessity for the minimum of a  
7 16-hour cell. I think that should be the manufacturer's  
8 option. There are techniques which allow you to charge  
9 immediately after filling.

10 FORD: I believe that same question in some of  
11 the comments came up yesterday in regard to the filling.  
12 I think we may get into that this morning.

13 As I said, I have no further comments, specific  
14 comments, in regard to chapter 7. At this time I'd like to  
15 open the discussion for general comments in regard to this  
16 chapter, if anyone would care to make them -- philosophical  
17 type comments, et cetera.

18 SULKES: Sulkes, U.S. Army Electronics Command.

19 I don't find any place where the state of charge  
20 of the cadmium is adjusted. Have I missed something?

21 FORD: No, you did not. It is not in here at  
22 this point. It will be included.

23 SULKES: Once you've pinched off the tube, you've  
24 had it.

25 FORD: Agreed.

1           BOGNER: Bogner, JPL.

rms 16

2           A couple of comments concerning the electrolyte  
3           fill. I don't know if anyone has established how much  
4           carbonate you can stand in the cell, but maybe this oper-  
5           ation should be carried out in the glovebox to eliminate  
6           all possible contamination from CO<sub>2</sub>. And I haven't seen  
7           anything in the specification that says how the KOH should  
8           be stored. I think it's initially mixed up when you measure  
9           the CO<sub>2</sub>. And from there on in nothing is said how it's  
10          stored or how it's handled, and I think I've seen some  
11          instances where it can be exposed to the atmosphere.

12          HALPERT: I would like to make a comment with  
13          regard to Sid Gross' comment earlier, and that is somebody  
14          made the statement yesterday that they were testing the  
15          hell out of these plates and cells, and I can't -- since  
16          we are doing quite a bit of testing on these materials to  
17          make sure they are reliable and to make sure they meet a  
18          certain quality, if we run into a problem with shorting or  
19          any other problem, I don't see why we just don't put them  
20          aside.

21          Why bother to rework them? Are the materials  
22          that expensive where we can't do it? Or can they not be  
23          used in some other application by Aerospace? I don't see  
24          the reason for continuing to work with something that is  
25          shown to be not within the proper tolerances that we're

1 trying to show here. Maybe I can get some further comment  
rms 17 2 from others.

3 GROSS: I want to put them aside and then  
4 straighten out the process, so it will never happen again.  
5 There's something wrong for that to have happened.

6 RAMPEL: Rampel, General Electric. 7.4.10.1 (b).  
7 After you put KOH in the cell it would be extremely diffi-  
8 cult to check the cell for a leak rate. It would be  
9 difficult to pump it down with that KOH in there.

10 FORD: This is a cell with a gage assembly.  
11 Supposedly this cell is sealed. I am not sure I follow  
12 the logic behind your comment.

13 VOYENTZIE: Voyentzie, GE.

14 I think the thing is here with the valve on it  
15 you would face helium hang-up. And if you're trying to  
16 pump down a group of cells for helium leak detection pur-  
17 poses you'd still have gas in that valve hole. It would  
18 be really difficult to get out.

19 GROSS: Gross, Boeing.

20 One of the important weak links I think I see  
21 is in item 7.4.3 where we say that we will perform the  
22 formation as per the manufacturer's schedule. In this  
23 section we've directed our attention to what happens after  
24 the manufacturer's schedule, and we're talking about the  
25 final formation discharge.

rs 18

1 Now, prior to the final formation discharge all  
2 kinds of black magic and bad things can happen. If we  
3 don't do a real good job during the formation, we're  
4 naturally asking for trouble. So, his formation schedule,  
5 whatever it is, should be very definite, very consistent,  
6 should be very repeatable and should be held rigidly. It  
7 should not be at all flexible.

8 GASTON: Gaston, Grumman.

9 I have a comment on paragraph 7.4.9.5 (c). It  
10 says, "Or other metal which is non-corrosive in KOH  
11 environment." I think it should be defined a little bit  
12 closer, what non-corrosive means. And possibly stainless  
13 steel type should be defined.

14 CARR: Carr of Eagle-Picher.

15 I'd like to respond to Jerry Halpert's desire.  
16 I think, Jerry, that we should have a section in the  
17 specification regarding the treatment of rejects, or the  
18 treatment of problems and whether it be a MRB, a material  
19 review board, or some other method, I think it would be  
20 quite applicable here to define the types of defects  
21 that we're concerned with and the types of procedure we  
22 would follow if we had them.

23 This could be done by referencing other standard  
24 inspection procedures, military standards, or NASA docu-  
25 ments or writing out specifically what we want for battery



1 cells.

2 FORD: Other comments?

3 HALPERT: I would agree with that and say that  
4 there should be some feedback into the process, as Sid  
5 has suggested, so that we can find out and at least clear  
6 up where the problems were, and the next set would hope-  
7 fully eliminate that particular problem.

8 CAPR: Right. I agree. Our standard procedures  
9 include this. And our silver zinc, nickel cadmium and  
10 other battery manufacturers for space programs and other  
11 high reliability type units -- you have to assign the cause  
12 of the problem, in other words, the analysis of the  
13 problem in order to determine the corrective action. And  
14 I think it is absolutely required.

15 MAURER: I have a comment.

16 I'm a little confused about this question. As  
17 I understand the question on leak detection, you are saying  
18 that it was impractical to leak check with the electrolyte  
19 in the cell because it was difficult to pump it down. My  
20 understanding of the reading of this spec is that the leak  
21 testing is done in the reverse direction. The cell is  
22 filled with helium and you look for helium on the outside,  
23 syou you're not pumping down the internals of the cell  
24 particularly during the leak check operation.

25 VOYENTZIE: Voyentzie, General Electric.

rms 19

rms 20

1 I think that my comment was associated with the  
2 fact that you have a group of cells sitting in a Bell  
3 jar which you've just filled with helium and you've got  
4 these valve assemblies on them. And pumping the remaining  
5 helium out of these valve assemblies could be rather diffi-  
6 cult. They'd have to sit there an awfully long time  
7 before you cleared the helium hang-up.

8 MAURER: All right. 884 //

9 FORD: Other comments?

10 MC CALLUM: McCallum of Battelle.

11 I have a feeling that when you specify these  
12 capacities rigorously, like you have 1.3 times the positive  
13 plate and so on that you ought also to specify weight  
14 gains back in paragraph 2.2.1.5, you ought to put a weight  
15 gain in there.

16 RUBIN: Rubin, TI.

17 I take exception to the use of weight gain data  
18 because it is misleading and it does not give you an  
19 accurate representation of the amount of active material  
20 that's in your plate. In normal impregnation procedures,  
21 be it the nickel or the cadmium plate, you get black  
22 corrosion. And by using weight gain data you're getting  
23 misleading values which give you things like 110 percent  
24 efficiency of utilization material which obviously is  
25 absurd.

rms 21

1           MCCALLUM: It seems to me that your objective here is  
2 reliability and reproducibility. And here is a man saying  
3 that he's got a critical step in his process that doesn't  
4 mean a thing. And I don't see how he can say that and at  
5 the same time say he is going to give you a reproducible  
6 cell. So, he ought to pin that down in my opinion.

7           NIETZEL: Nietzel, TI.

8           Jerry, would you please read our comment to  
9 paragraph 2.2.1.5 that we gave you yesterday in which a  
10 complete analysis was given of what we do to determine  
11 active material loading and what requirements are involved  
12 before and after impregnation?

13          FORD: Would you repeat the paragraph number?

14          NIETZEL: 2.2.1.5.

15          FORD: Okay.

16          Paragraph 2.2.1.5. The stated method of control  
17 and measurement is inadequate. The number of impregnation  
18 cycles can vary appreciably depending on the method of  
19 plaque manufacture as well as impregnation techniques.  
20 Therefore, the number of these cycles is of use for a  
21 given manufacturer and may not be readily compared to the  
22 other processes.

23          To determine the necessary attribute for con-  
24 trolling the impregnated plate, weight gain data is in-  
25 sufficient and misleading. This measurement in no way

rms 22

1 corrects for plaque corrosion which varies measurably between  
2 positive and negative plates (and process-to-process)  
3 and in no way can measure the degree of plaque corrosion  
4 which affects the ultimate strength of the plate substrate.

5 To determine the quantity of active material  
6 present in converted and/or foreign plates precise analyses  
7 including --

- 8 1. Sintered weight per unit area before impreg-  
9 nation.
- 10 2. Substrate weight per unit area before impreg-  
11 nation.
- 12 3. Sintered weight per unit area after impreg-  
13 nation.
- 14 4. Plate weight per unit area after impreg-  
15 nation.
- 16 5. Quantity of nickel, cobalt, cadmium, hydroxides  
17 and or metals present, must be performed and documented.

18 Using this type of analysis active material  
19 measurements can be made.

20 HENNIGAN: We had a suggestion for a topic of  
21 discussion as to how cadmium exists in the negative plate,  
22 and Art Fleischer has volunteered to say a word or two on  
23 that.

24 FLEISCHER: In listening especially to yesterday's  
25 talk about the ratio of cadmium in various forms, everybody

rms 23

1 has a different name for it, I think we ought to clarify  
2 what it is we're really talking about. If you impregnate a  
3 sintered plate -- and let's talk only about the negatives  
4 now -- you analyze that plate for its cadmium content which  
5 is roughly the suggestion that has just been made that  
6 we know exactly how much cadmium or how much active nickel  
7 is in the plate.

8 To my knowledge, no one has ever gotten a  
9 coefficient of utilization greater than 80 percent out of a  
10 sintered plate. In other words, even at the very lowest  
11 rate of discharge and the most favorable conditions of  
12 charging and of absence of gases within the pores of the  
13 plates as a result of charging, you will get somewhere around  
14 80.

15 Now somebody might have gotten up to 82 percent  
16 coefficient of utilization, so the first problem we're  
17 faced with is there is 18 percent of the cadmium present in  
18 a form which does not respond electrically. In other words,  
19 it does not contribute directly to the performance of  
20 the cell. It may do it indirectly because there may be  
21 reasons why we can't get above this coefficient of utili-  
22 zation. So, the first thing you have to do is we're  
23 talking about 80 percent of the cadmium we put in, and  
24 this is a capacity that we have determined under a given  
25 set of conditions.

rms 24

1 Now, then, this 80 percent has to be divided  
2 into three poritions, as I understand it, the part that  
3 is the working cadmium, the part that is the precharged  
4 cadmium, and the part that's uncharged, in other words, to  
5 prevent hydrogen evolution, because we're talking about  
6 sealed cells.

7 So, we divide our cadmium into four portions and  
8 we come out that we should know the total amount of cadmium  
9 in the electrode, and this you can only determine by  
10 analysis. So, we do have a problem here in defining what  
11 we're talking about.

12 I think that Lou Belove yesterday was talking  
13 about the total cadmium in the plates. I may be mistaken.  
14 He said he advocates a ratio of 1.8 to 1, so he meant the  
15 total amount of cadmium in the plate, but this really isn't  
16 a meaningful figure because unless I'm mistaken, this 20  
17 percent of cadmium we don't quite understand its function.

18 Let's face it. Do we? I don't know of anybody  
19 who has ever come up and said the reason that this 20 per-  
20 cent doesn't work is for the following reason and then  
21 demonstrated it. Because if he could do that, then he  
22 probably could get rid of that 20 percent and be at an  
23 advantage over everybody else, if he knew how to do this.

24 So, we should define exactly what it is we're  
25 talking about with relation to cadmium. And in order to get

rms 25

1 it going you'll have to do a chemical analysis for  
2 cadmium. You will have to know what the cadmium content  
3 is.

4 HENNIGAN: Do we have any more comments on the  
5 negative plate?

6 LANDSMAN: Landsman, MIT.

7 This weight gain that we're talking about not  
8 measuring -- or I think that's what we were talking about --  
9 it still doesn't hurt to include it so that you have a  
10 record of it. That's what we've been talking about, we've  
11 just got records. We don't know whether we're going to  
12 use it or not, but we're going to have some record. And we  
13 can compare the future production with the past production.

14 NIETZEL: The purpose of processes, you do not  
15 want to waste your time collecting data that is interpret-  
16 able. You're here supposedly as a technical individual to  
17 try to understand what data you're collecting and how to  
18 use it.

19 If you can't use weight gain, and believe me, you  
20 can't, and I'll stand on that one, then let's not waste  
21 our time doing that and let's devote our energies to some  
22 type of technique where you can collect the data and use it  
23 as a function of controlling your processes.

24 FLEISCHER: No one commented on that remark. To  
25 a great extent Nietzel is right, but on the other hand, we

rms 26

1 all know that every company has a bookkeeping department to  
2 keep a lot of records. As far as I'm concerned, they might  
3 as well burn them up, they don't mean anything, and yet  
4 it's a very expensive part of the business. You keep  
5 records about what you pay people and so on, and yet the  
6 only thing that really counts is how much profit are you  
7 making.

8 Well, we have the same thing here. We have to  
9 do a certain amount of bookkeeping in order to know that  
10 our quality and our reliability is going to show up. I  
11 don't see how you can avoid this. It's just a part of the  
12 job. You're going to have to have records. Now, I don't  
13 know what the minimum amount is or where you should stop,  
14 but somewhere along your process this is going to fall out.  
15 You have to do it in order for yourself to know what  
16 you're doing. How do you know that somebody didn't violate  
17 the rules, he impregnated for five minutes instead of for  
18 ten minutes, or whatever the cycle is. There's always  
19 somebody doing something. They set a thermometer on a  
20 furnace or a thermocouple on a furnace to control at  
21 1800 instead of 1700 and so on. You have to know what these  
22 things are. And you have recording instruments and you  
23 have records kept of what is going on.

24 NIETZEL: I would like to answer it this way:

25 All right, you mentioned certain specifics. Let's look at



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1 sintering. All right. A difference of 100 degrees in a  
2 sintering temperature. If your process is properly set  
3 up and your quality program is set up, you can recognize  
4 not 100 degrees shift in your sinter temperature, you can  
5 get down to around a 25 degree shift in sinter temperature  
6 and recognize the difference in your ultimate parameters.

7 Now, my personal philosophy is this. Manufacturing  
8 is quality control -- period. And when I ask my people to  
9 take data that is going to be usable to them, they can  
10 sense when they're collecting data that I will not use, our  
11 engineering people will not use, our quality assurance  
12 people will not use. And they say to themselves why do it?  
13 And that's what I say -- why do it?

14 If you're going to take the time to collect data,  
15 let us take data that is useful for the process control.

16 BELOVE: Belove, Sonotone.

17 As far as I can understand, one of the purposes  
18 of this specification and NASA's deep concern with the  
19 nickel cadmium product in all batteries is to be able to  
20 obtain traceability, because all of us know we can anticipate  
21 some failures, and one of the reasons is to be able to trace  
22 back and find out what caused this failure. And if you are  
23 to do this, then you must maintain every record, even those  
24 about which you may not know the importance at the moment.

25 Weight gain -- in our experience weight gain does

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1 not actually accurately describe the capacity of the cell.  
2 Nevertheless, if the weight gain shifts considerably I  
3 think the customer may want to know whether this was  
4 directly concerned or indirectly concerned with a shift  
5 in product performance.

6 NIETZEL: Nietzel, TI.

7 If a process outline is set up and then you notice  
8 a shift in so-called "weight gain", obviously the process  
9 is out of control and the product shouldn't end up going to  
10 the customer anyway. So, what does he care about it?

11 MAURER: We've been looking at the weighing of  
12 the negative electrodes before it goes into the cell for  
13 the purpose of determining its weight gain. There's another  
14 use for this type of data and that is that 10 years from  
15 now when John takes a cell apart to see what made it fail  
16 or what made it last ten years, he might like to know that  
17 figure to see whether the negative plate increased or  
18 decreased in those ten years.

19 (Laughter.)

20 NIETZEL: Nietzel, TI.

21 If as a function of your process you end up  
22 determining the weight per unit area of your impregnated  
23 plate and you know the weight per unit area of your plaque  
24 prior to impregnation, you can call that "weight gain," and  
25 still use that number. What I'm saying is that weight gain

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1 cannot be used as a process control system. That does not  
2 mean you don't have the weight gain. You can go back in.  
3 You should know what your plaque is weighing before you  
4 impregnate it. That's the only way you're going to be able  
5 to control your plaque process is to know what's happening  
6 in terms of sinter weight per unit area. And you must have  
7 some measurement of your final plate prior to analysis  
8 if you're going to end up with percent corrosion and a  
9 percent cadmium, percent nickel on whatever forms you want  
10 to look at it.

11 So, that data is available. The problem is how do  
12 you use it.

13 FLEISCHER: I'm going to agree with Neitzel for  
14 a minute here just to give him small support. There's one  
15 part of the weight gain business that we haven't talked  
16 about, and that is when you impregnate these plates there's  
17 always a surface coating of nickel hydroxide or of cadmium  
18 and cadmium hydroxide. And I think this is the principal  
19 problem in this thing. If it weren't for that coating  
20 that you don't want on there and eventually you scrub  
21 off, you could probably relate weight gains to our particular  
22 process and the distribution and amount of nickel hydroxide  
23 that's formed by corrosion, and the same thing applies in  
24 the negative plate, you'll know what the distribution of  
25 cadmium is in terms of cadmium hydroxide and cadmium.

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1 But there's no way of estimating how much material  
2 is on the surface of the plate, and it might be a lot and  
3 it might be a little. It depends on a great variety of  
4 conditions depending on how often the sodium hydroxide  
5 has been used in the polarization and so on and so forth,  
6 so I think from that point of view you're absolutely right  
7 that sometimes these figures are puzzling. But they do  
8 guide you in your control that everything is going along.

9 Sometimes you get sintered plates which have  
10 been sintered and for some reason, maybe related to the type  
11 of powder, the properties of the power, the plates don't  
12 impregnate properly, and you detect this right away on your  
13 first cycle in manufacturing. You may not have caught this  
14 in your control of the plates. So, there's a reason for  
15 having weight gain. You can't rule it out.

16 So, I started out agreeing with you, and now I  
17 disagree.

18 (Laughter.)

19 NIETZEL: I'll let Ed Rubin take over here.

20 RUBIN: Rubin, TI.

21 If you gentlemen listened to the five points  
22 that Floyd Ford just read off, you will understand that  
23 weight gain can be calculated from the information that we  
24 say is necessary to understand the chemistry of the positive  
25 and negative plates.

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1 I think this discussion has gotten off to the  
2 point where we're talking about something that didn't start  
3 out, and that is if you're making a measurement, make  
4 sure you know what your're measuing and make sure you know  
5 how you can use that measurement to control your process.

6 In the transcript you'll see if you add up items  
7 one and two and subtract that from item four, that gives  
8 you a weight gain. What we're saying, go deeper than that,  
9 understand how much of your plaque you corroded, under-  
10 stand how much nickel hydroxide appears in your negative  
11 plate. Then you'll have a better feel for what your  
12 plate actually has in terms of chemically active material.

13 MC CALLUM: McCallum of Battelle.

14 I'd like to re-emphasize an original point that  
15 with all these problems being discussed I can't imagine  
16 how you're going to solve them all by saying that if the  
17 ratio of the electrical capacities is 1.3, then all these  
18 other numbers can be whatever you want just so you have an  
19 electrical capacity of 1.3 is not enough.

20 FLEISCHER: John, who said that?

21 MC CALLUM: Paragraph 7.4.3 (g) and (d). (g)  
22 gives you 1.3 plus or minus .05 and in essence says if you  
23 satisfy this you can have any weight gains you'd like to  
24 have or any other variable just so you end up with this  
25 electrical ratio.

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1 FLEISCHER: The battery men don't get up and  
2 talk for themselves on this. Isn't this a point that the  
3 committee took in hand that they cannot tell the battery  
4 manufacturer how to make their plates. And they have to  
5 specify some electrical quantity which they can meet which  
6 is reasonable. Now, what you're telling us I think is that  
7 we have to tell them how to make the plates.

8 MC CALLUM: I was suggesting that you give a  
9 weight gain on paragraph 2.2.5 -- 2.2.1.5 -- that if you're  
10 going to specify an electrical rating and the 7.4.3, you  
11 ought to specify some kind of a weight number over in  
12 2.2.1.

13 FLEISCHER: I think the battery manufacturers  
14 ought to answer that question.

15 NIETZEL: Would you repeat it, please. What was  
16 the question?

17 FLEISCHER: We're talking about -- John, do you  
18 want to repeat that paragraph? I've lost it here.

19 MC CALLUM: The question I guess is whether you  
20 can specify in paragraph 2.2.1.5 a weight gain number that  
21 will give you the electrical requirement in paragraph  
22 7.4.3 (g).

23 NIETZEL: If we really take a look at this now, I  
24 think it's starting to be self-evident that they're not  
25 compatible. The paragraph on weight gain merely states

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1 that it is to be recorded and supplied. It does not say  
2 it is to be interpreted. So they are incompatible. And  
3 that's the point that we've been trying to make and that  
4 is that 2.2.1.5 does not really give you the information  
5 you're looking for. And we offered an alternate to that.  
6 All right?

7 MC CALLUM: As I understood your alternate, you  
8 were giving an alternative set of data to be recorded, and  
9 it still can be any number that any manufacturer wants  
10 to record, just so he records it, and the question is  
11 whether you can give a number in paragraph 2.2.1.5 which  
12 will lead to the requirement in 7.4.3 (g).

13 REED: Reed from Battelle.

14 If I could comment on that, I think the answer  
15 to the previous question is probably no, you cannot  
16 specify a weight gain that will give you this ratio because  
17 we've just learned from various manufacturers that the  
18 amount of active material which you must impregnate to get  
19 a certain electrical capacity is a function of the process  
20 which is used.

21 HALPERT: I would like to ask the question then:  
22 Since I was responsible for writing up this area, how  
23 would one then make a specification or put a specification  
24 here that would give you the requirement in section seven.  
25 Does each manufacturer have a weight gain which is related

1 to the weight gain corrosion content which is related to  
2 capacity? And if they do, are they willing to supply it  
3 for each case?

4 RUBIN: Rubin, TI.

5 First of all, I don't necessarily accept 1.3 as  
6 an absolute value, but if a user came to TI and said that  
7 he wanted a negative to positive ratio as specified in  
8 section (g) here of 1.3, then we have the chemistry  
9 available to manufacture specifically that type of ratio.

10 Again, in talking about this ratio, not all appli-  
11 cations should have a 1.3 plus or minus .05, but if that is  
12 what is desired by the user, that can be made using and  
13 implementing the analytical data that's available. And  
14 that will be presented to the user in specification form.  
15 That's what we do now.

16 FORD: I'd like to clarify a point on that partic-  
17 ular paragraph that's so deep in discussion. If you read  
18 the paragraph it implied but it is not explicitly stated  
19 that this is to demonstrate that that capacity is there.  
20 The tolerance is misleading. It should be a minimum of  
21 1.3. Anything above that is not to be rejected.

22 RUBIN: There are very few things that I reject  
23 out of hand, but one of them is an open-ended tolerance.  
24 I would recommend that if a user understands the nickel-  
25 cad process sufficiently to specify what he considers for



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1 his application, a reasonable ratio, then he should so  
2 specify it to the manufacturer to indicate what tolerance  
3 he can hold out to. Now, if the user feels that's reasonable,  
4 then he can buy it. If not, then it has to be discussed.  
5 But that ratio can be closely controlled even to the mis-  
6 interpreted tolerance that I put on it. I object to open-  
7 ended tolerances.

8 FORD: If I understand what you're saying, you're  
9 saying that the specification should include a ratio  
10 number with a minimum and a maximum?

11 RUBIN: No. This specification should allow  
12 a manufacturer to design the cell for an application. I'm  
13 a firm believer that the negative to positive ratio is  
14 a design parameter, and it cannot be used universally for  
15 all applications. Some applications -- 1.3 is insufficient,  
16 or you'd have to go to two to one. But that is a design  
17 parameter.

18 For most space applications that I've seen this  
19 type of ratio is reasonable, but I would say that when a  
20 user buys a battery or cell and he wants a certain ratio  
21 that it should actually have a tolerance on it and not be  
22 open-ended.

23 SULKES: Sulkes, U.S. Army Electronics Command.

24 One problem where you're specifying 1.3 is that  
25 once the plate stack gets further processing that ratio

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1 can be completely lost in that there may be an excess of  
2 cadmium hydroxide available, and the actual ratio as you  
3 get further downstream may end up one-one, one to 1.2  
4 or anything.

5 At the place you've specified it, it doesn't  
6 really control the final cell. I think it has basically  
7 no meaning, because by formation charging and by how far  
8 you deep discharge, you can control it anyway you want.

9 I mean if you just want to have them come up  
10 with this number, it really doesn't give you your final  
11 cell to do what you want.

12 FORD: Are you referring to precharge?

13 SULKES: Yes, in other words, you've precharged.  
14 You've run this test, but after that there's a lot more  
15 processing that goes into it. And the state of charge or  
16 this balance can change all over the lot.

17 FORD: Well, I might comment this time. It is my  
18 personal feeling that at this point this particular para-  
19 graph will be changed to read that the negatives will be  
20 discharged completely during this period.

21 Are there other comments?

22 GROSS: Gross, Boeing.

23 I would like to hear comments from people on how  
24 to resolve the question of definition of cadmium capacity  
25 that Art Fleischer discussed. He presented the problem. It

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1 has to be solved. Are we going to talk about theoretical  
2 capacity, or what are we going to do? How are we going to  
3 solve the problem of definitions.

4 FORD: I think there's another section -- I'm not  
5 sure which chapter it is -- where it's called a ratio test.  
6 And we'll probably be getting into that a little deeper.  
7 I think that will be discussed before the day is over.

8 GASTON: Gaston, Grumman.

9 I have two specific comments. One of them is on  
10 paragraph 7.4.9.5 (d). It says, "Place jackets on cells."  
11 I think jackets should be defined a little bit closer.  
12 They shall be parallel and certainly they shall not warp  
13 after restraining(?). So possibly some additions could be  
14 made on this specific item on jackets.

15 The next comment I have is on paragraph 7.4.10.1(a).  
16 It says, "Backfill with helium." Possibly a certification  
17 of helium would be desirable or an analysis be conducted on  
18 the helium.

19 FORD: You mean for impurities?

20 GASTON: For impurities, yes.

21 FORD: We are going for a coffee break in a  
22 few minutes, so I'd like to contain the discussion up until  
23 that time, because after the coffee break I think we'll  
24 probably go into another area.

25 CARR: Carr of Eagle-Picher.

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1 I'd like to just discuss one other thing we've  
2 hit on a few times and that's the carbonate problem. I  
3 might ask for some support from the gentleman from Battelle  
4 and the gentleman from the Canadian Defense establishment.

5 It seems to me that we're talking about two  
6 different types of carbonate, or let's say we're worried  
7 about two different types of carbonate. One, the carbonate  
8 that we're introducing into the cell as a result of con-  
9 tamination from the atmosphere of either plates or electro-  
10 lyte. And then there is the problem of the separator  
11 resulting in carbonate. Now, it seems to me that the  
12 orders of magnitude are somewhat different. And I'm  
13 wondering if maybe the controls are more unrealistic than  
14 they should be during the manufacture, such as the plus or  
15 minus 3 minutes type of thing, as compared to what actually  
16 happens when the battery is used.

17 FORD: Would anyone care to comment on that?  
18 Or question it?

19 REED: Reed from Battelle.

20 I'll try to comment on that just a little bit, if  
21 I can. I don't know whether I'll answer the question  
22 satisfactorily. But it appears from evidence more in the  
23 literature and also some that we have that carbonate in the  
24 cell in low quantities is not particularly detrimental to  
25 cell performance.

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1 Now, what you define as low, obviously is going  
2 to depend on your operating regime. However, it appears in  
3 general that a concentration of carbonate on the order of  
4 100 grams per liter, or about 25 percent of your total  
5 KOH converted to carbonate is definitely detrimental to cell  
6 performance.

7 Now, then, we're talking first of all the total  
8 carbonate in the electrolyte back in a paragraph which I've  
9 forgotten. The original specification recommended .01 grams  
10 per liter which I feel is way too low.

11 Dr. King mentioned a figure yesterday I believe of  
12 4 percent, which in 30 percent KOH is more like 50 grams  
13 per liter. Now, certainly you don't want to start out with  
14 your KOH at that concentration of carbonate. However, it is  
15 possible without great difficulty to make KOH with a couple  
16 grams or less of carbonate per liter.

17 Now then, of course, it's going to pick up from  
18 various portions in the manufacturing process and from the  
19 separator, so we want to start out with a low concentration  
20 and assume that it will increase some.

21 The idea, of course, is to have enough process  
22 control that eventually the concentration of carbonate will  
23 still be below the somewhat critical concentration for  
24 operation of the cell.

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1 I worked on a project with Inland Testing for Wright-  
2 Patterson in which four different manufacturers, as I  
3 remember, of nickel cadmium batteries were cycled on various  
4 regimes at various temperatures, and in setting up the  
5 program we allowed for taking one sample right at the start  
6 of each group put on test. These cells were sent back to the  
7 manufacturers for their analysis.

8 And one of the surprising things that came out  
9 in two of the manufacturer's cells there was a carbonate  
10 content of about 130 grams per liter right at the start.  
11 So, the question was how did this come about. And it very  
12 soon came out that the plates that were used in manufacturing  
13 these cells had been set aside after their formation and  
14 allowed to stand around for two or three months, or so it  
15 was reported. So, they were thoroughly carbonated.

16 So, the principal source of contamination here was  
17 due to negligence in storage, taking the proper care. Now,  
18 there has to be some way in which the user can be guaranteed  
19 that this doesn't happen, because it was sort of ridiculous  
20 to run that very expensive test which had an aim in trying  
21 to find out how to run a failure analysis and how to run a  
22 cycle life test to determine what the probable life of a  
23 battery was.

24 And here two of the four manufacturers sent cells  
25 which had carbonate contents which are just not tolerable.

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1 So that the tests actually for the original purpose had no  
2 meaning. And well now what does the user do about this?  
3 Should he have gone back to the manufacturer and said look  
4 these cells are not acceptable, give us back the money.  
5 What about the cost of the testing?

6 These are very serious things, and I don't see any  
7 way of settling this problem unless we put it into a  
8 specification.

9 KING: King, Ottawa.

10 I'd like to say just one or two words on the  
11 carbonate. First of all, I'd like to agree with Dr. Fleischer.  
12 We find that most of our trouble emanates from the plate.  
13 And if we find large amounts, we remove it from the cell, get  
14 it down to the proper percentage.

15 Now, in mentioning yesterday four percent, this  
16 was a cell content and not the electrolyte used. In the  
17 electrolyte it's usually less one percent, and you will find  
18 a pick up in your cell, up to below 4 percent. And this is  
19 coming mainly from the plate and not from our separator.

20 FORD: Dr. King, I would like to ask you a question  
21 along those lines. Do you normally pull sample cells from  
22 production and do some type of test to determine the carbonate  
23 content on flight type cells?

24 KING: I would say that's 100 percent.

25 RUBIN: Rubin, TI.

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1 In referring to the carbonate problem, work done  
2 at TI indicates that you can actually manufacture carbonate  
3 within your cell after it's sealed. And this occurs because  
4 of a chloride ion that's present in some separators. Now,  
5 there is a reaction that occurs between a positive plate  
6 and a chloride ion that forms a hyper-chloride compound  
7 which in turn reacts with a secondary amine group on the  
8 Pellon separator and undergoes what is known as a Hoffman  
9 degradation, and this tends to split off certain chains  
10 within the separator and the decomposition product is CO<sub>2</sub>,  
11 which of course in the cell environment is converted to  
12 carbonate.

13 So, even under the most scrupulously controlled  
14 conditions you can under certain circumstances -- we have  
15 shown this in laboratory studies -- produce carbonate  
16 within a sealed cell.

17 FLEISCHER: Everybody expresses the percent  
18 carbonate in the electrolyte differently, and this is a  
19 small point. I think King is talking about the percent of  
20 potassium carbonate in a solution. I like to talk about  
21 the percent of carbonate on the equivalent basis, because  
22 then all you have to do is to divide the results of the  
23 titration. You actually have to do no calculations whatever.  
24 You just calculate -- your readings, you divide the carbonate  
25 part by the total titration. There's a little equation you



1 set up. It's very simple. You can do it in your head. And  
2 that gives you the percent of carbonate. So, you have no  
3 further worry about anything. You don't have to know the  
4 equivalent rates. You don't have to sit down. And anybody  
5 can do it. So, I think we haven't done it in here and it  
6 would be a good idea if we all agreed that the way to  
7 express the percent carbonate is by equivalents. That's  
8 the answer you get in the titration.

9 RICHARDSON: What value?

10 FLEISCHER: You have a total alkalinity of the  
11 cell which is what you titrate, the KOH plus  $K_2CO_3$ , that's  
12 your total titration. That is the number of equivalents.  
13 So, you also have the titration for carbonate. So, you  
14 divide the two figures, and that's the percent of carbonate  
15 by the equivalents.

16 RICHARDSON: What is the acceptable value of KOH?

17 FLEISCHER: Oh, you mean of carbonate?

18 RICHARDSON: Yes.

19 FLEISCHER: Oh, it's somewhere around three or  
20 four percent. I've forgotten the relationship. It is small.  
21 If you can keep it there, then you have no worries. It  
22 doesn't matter how you express it. But it's when it goes up  
23 that you have to worry.

24 KING: I would just like to mention to Dr. Fleischer  
25 that I did use the term two equivalent percents yesterday.

1 We use that in the lab but for outside we use weights.

2 MAURER: I would like to comment on the utilization  
3 of positive to active material. I think Ed commented  
4 that the utilizations of greater than 100 percent of the  
5 theoretical active material on the plate were ridiculous  
6 because you may not have calculated the weight of active  
7 material on the plate properly.

8 I agree that that's one source of error. The other  
9 source of error, however, is that you haven't used the  
10 proper theory. Most people use the one electron transfer  
11 and there is a possibility of other things happening.

12 RUBIN: I agree. And even if you use more  
13 reasonable values of a valence change, using the weight  
14 gain data will still give you those misleading results.  
15 But even using values that are arrived at like 1.2 electrons,  
16 you can arrive at those values by looking at the valence  
17 of the nickel, by analytical means, even using that  
18 correction factor, you'll still, if you use weight gain  
19 data, will get values of greater than 100 percent.

20 NIETZEL: Nietzel, TI.

21 One comment I was going to have here on this  
22 three-minute time period. My personal concern on that is  
23 not so much the problem of carbonate pick-up but the problem  
24 of losing your free cadmium adjustment because of oxygen,  
25 and therefore indiscriminately leaving these things open,

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1 you know, you'll end up losing that whole thing.

2 RICHARDSON: Richardson, Marshall.

3 On that 523, it's still not clear in my mind  
4 what is the acceptable weight carbonate concentration. The  
5 spec shows .01 grams per liter. Is this a realistic  
6 value that we ought to set, or is two or three grams per  
7 liter more realistic or what?

8 FORD: I will answer your question in a minute.  
9 Dr. McCallum has a comment. I do have an answer to your  
10 question.

11 NIETZEL: In terms of the .01 grams per liter,  
12 our comment on that was to convert that. We thought we  
13 should see their 01 moles per liter. My personal  
14 recommendation would be 10th molar. And I think that can  
15 be controlled very easily. Inert gas flowing over after  
16 you mix your material. Put a blanket and then you won't  
17 have any problems.

18 MC CALLUM: McCallum, Battelle.

19 I was wondering if our friend from TI could comment  
20 on his remark that he can control the electrical ratio, 1.3,  
21 very closely and get the customer any number he wants, but  
22 that the weight gains are not the way he does it. And I  
23 wondered if he could tell me how he does that, if it isn't  
24 by weight gain.

25 NIETZEL: For a small investment you can come up

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1 and see us, and we will be glad to tell you.

2 (Laughter.)

3 There are people on the panel who are aware of  
4 how we do that, and I am confident that they understand our  
5 systems. It is not an Ouija board. It's supposed to be  
6 science. And I say we can do it. People on the panel board  
7 know we can do it. And I didn't mean that as a sales pitch,  
8 but it can be done.

9 And I have a feeling that there's a few other  
10 people around here that are catching on pretty fast on how  
11 to do it.

12 FORD: Are there any other comments before we  
13 take a coffee break.

14 RICHARDSON: Floyd, you're going to answer my  
15 question.

16 (Laughter.)

17 RICHARDSON: I'm asking you. That's his opinion.

18 FORD: I don't know what the answer is. No, I'm  
19 not going to answer it.

20 RICHARDSON: Okay.

21 (Laughter.)

22 (Coffee break.)

23 HENNIGAN: I would like to call the meeting to  
24 order for the second part of the morning session.

25 One thing I would like to repeat is a statement

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1 that I read yesterday morning, so we don't get too far  
2 afield. The statement read as such: It was not the intent  
3 of NASA and industry personnel to attach the interim spec  
4 to purchase requests and require the battery industry to  
5 conform overnight. This would have been impossible. The  
6 spec was given wide distribution so that users could have  
7 a document from which they could take information to be  
8 incorporated in their own specifications where they saw a  
9 need.

10 It has been noted that in several instances this  
11 has been the case. It is my feeling that a uniform specifi-  
12 cation would be useful in approaching standardization and  
13 obtaining a basis for bidding on purchase requests. We  
14 kind of felt that maybe we should repeat that statement.  
15 And this is a model specification, and it has to be revised  
16 so that it will be generally acceptable to manufacturers  
17 and users.

18 There is one other point that our chairman brought  
19 up. The spec as written is for prismatic cells, as stated  
20 in paragraph 1.1. And it does not cover cylindrical cells.  
21 At the time we sat down to write this spec we felt that  
22 the wide use of prismatic cells at this time would not  
23 eliminate the cylindrical cells, but that we feel would take  
24 a separate specification.

We have also noticed that people seem to be a little

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1 bit worried about the extensive testing. Probably what we  
2 have to do is have two types of testing -- qualification of  
3 materials and components as they are going through a  
4 process. Now, for instance, if a batch test is run, we  
5 would feel that you wouldn't have to run this test on the  
6 batch every time you put through cells, if you felt this  
7 material was properly stored and did not change with time.

8 Now, some things I guess do change with time,  
9 like plates if they're stored, so some things would have to  
10 be run again.

11 One point that's well taken is the statistical  
12 sampling for testing per the mil spec, which a certain sample  
13 size is taken, if they pass, the lot passes. If they don't  
14 pass, you have to take a larger and larger sample. This is  
15 a well accepted technique.

16 We also appreciate the material review board  
17 approach. This seemsto be something that we feel -- the  
18 chairman felt was well taken and could be put into effect.

19 There seems to be a lot of worry about the cost  
20 of implementing this spec entirely or in part. And we do  
21 have some numbers that are practical numbers because they  
22 come out of bids and purchases.

23 I think Floyd Ford has an approximate number that  
24 showed the increase when the spec was taken entirely. Is  
25 that right, Floyd?

1           FORD: Yes. I will pass it on to Steve Gaston,  
2 where the spec was taken partly and included in a purchase  
3 for the recent OAO battery. Steve has an estimate of what  
4 the results were.

5           GASTON: I believe yesterday it was mentioned that  
6 approximately 60 percent of this new specification  
7 has been incorporated in the recent bid on the OAO battery  
8 cells. And a rough estimate is that the cost ratio is  
9 between two and three to one. That was before. Now it is  
10 between 200 and 300 percent of the original cost.

11          HALPERT: That is without section 2, right?

12          GASTON: Yes.

13          FORD: I would like to emphasize that is not  
14 referring to this particular spec that we're talking about  
15 here in the meeting.

16          HENNIGAN: The implementation is about 60 percent  
17 of it in a Grumman spec.

18          GASTON: Right.

19          HENNIGAN: Did you have any comments, Jerry?

20          HALPERT: Yes, I would like to, if I may, make  
21 some comments about the nickel powder which we have not  
22 even discussed in here. I guess it's an error of omission,  
23 but there are certain properties of the nickel powder itself,  
24 which we certainly want to consider -- shrinkage being one  
25 and possibly wetting another. And I'm sure there are some

1 other tests which you may want to recommend and the  
2 audience may want to make some recommendations on that.

3 As a second item, I wonder whether Mr. Mearns of  
4 International Nickel who is visiting with us today may have  
5 comments. We are in the midst of a nickel strike since  
6 July, and it may be of some interest on the status of that  
7 strike and the availability of materials, since we're  
8 talking about nickel cadmium cells that utilize quite a  
9 bit of nickel. And I wonder whether we're going to be  
10 affected at all in the future.

11 MEARNS: As you know, we are on strike. Inco  
12 and union negotiators continue to talk at the bargaining  
13 table as new efforts are made to end the Ontario nickel  
14 strike. On Monday, October 27, Inco made a wage increase  
15 offer of about \$1.33 an hour. Guessing in some circles is  
16 that the strike may end in November. That is the latest I  
17 know on the strike.

18 STEMMLE: What are the chances of getting nickel?  
19 Is there a good stockpile, or is there a shortage in, say,  
20 nickel sheet or nickel powder?

21 MEARNS: Everyone asks that question on a time-  
22 table. When the strike ends it will be sometime before nickel  
23 is available. Some are guessing it will take six weeks or  
24 so before nickel powder is available, and no set timetable  
25 is available.

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1 HALPERT: Another question if I may. I understand  
2 there is some contemplation of building a facility in Sudbury  
3 in Canada to provide these powders rather than getting them  
4 from way off. What is the status of that? Is there going  
5 to be a facility there?

6 MEARNS: I am not familiar with the plant or the  
7 schedule. We do have a new Inco pressure carbonyl (IPC)  
8 process, which is a development in chemical metallurgy for  
9 treating sulfide ores and intermediate concentrates which is  
10 scheduled for completion in the latter part of 1972. The plant  
11 will have an annual capacity of 100 million pounds in the  
12 form of nickel pellets and 25 million pounds in the form of  
13 nickel powders.

14 The IPC complex will also produce copper, cobalt  
15 and sulfur, and will be located at Copper Cliff in Canada.

16 MC CARTER: McCarter, Eagle-Picher.

17 If the strike is settled rapidly, how long will  
18 it be before we get back to where we don't have to have DO  
19 and DX to get supplies?

20 MEARNS: That's a question everyone asks us. And  
21 I don't think any of us know the answer. Some people say  
22 it will be four weeks and some people say it will be six.  
23 We don't really know.

24 GROSS: Gross, Boeing.

25 I would like to see the specification expanded to

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1 include not only the unmanned satellite applications but  
2 to give a little thought to the special problems of manned  
3 spacecraft. We know that safety will be an important factor.  
4 And I don't have any inputs that I could read off right now,  
5 but I would certainly like to see the specification expanded  
6 in that area.

7 HENNIGAN: Any other comments before we get on  
8 to the separator portion?

9 (No response.)

10 We will cover the separator portion of the specifi-  
11 cation which is paragraph 3.0.

12 On the first paragraph 3.1 which is concerned with  
13 the separator weight per unit area, we have two comments  
14 there. The conditions should be 21.1° C plus or minus  
15 1.1 and 65 plus or minus 2 percent relative humidity.  
16 This is per federal test standard number 191, which I under-  
17 stand is a test spec for textile materials.

18 The target spec of 60 plus or minus 1 gram  
19 per meter squared is not within the capability of the  
20 commercial facility. Our current specification is 60  
21 plus or minus 8 grams per meter squared. They feel they  
22 could hold 60 plus or minus 6 grams per meter squared.

23 Are there any more comments on 3.1?

24 (No response.)

25 HENNIGAN: On 3.2 the absorption, dimensional change,

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1 electrolyte retention and porosity.

2 The comment we have is that measurements should  
3 be made using an Ames gage or equivalent. Since a wet  
4 sample will be compared to a dry sample, weighing the dry  
5 sample to a tenth of a milligram seems to be unwarranted.

6 Jerry?

7 HALPERT: I would like to make a comment on that.  
8 On thickness evidently there are a number of different  
9 gages one can use to measure thickness, and everyone gives  
10 you a different answer. I don't really know whether we know  
11 what thickness is in terms of the separator in the cells,  
12 since when we put it together we squeeze it down to some  
13 other value other than what we started with.

14 I just make this comment that I think some stan-  
15 dard for thickness which may be more meaningful -- it should  
16 be more meaningful than any of these particular Ames gages --  
17 might be in order.

18 Maybe somebody has a comment about thickness measure-  
19 ment.

20 FLEISCHER: I took this matter up in one of my  
21 reports to Fort Monmouth. I can't remember the number. But  
22 I went into it very extensively. And roughly what we did  
23 was to use two quarter inch plates, steel plates that we  
24 had polished very carefully, and we put the separator between  
25 these plates.

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1 As I remember, the two plates together were  
2 .4 or .5 inches thick. And this was just the right amount  
3 of pressure, and it coincided with the references that were  
4 given there for achieving a meaningful thickness for woven  
5 materials and non-woven materials. But it is in that report.  
6 I went through it, and I've forgotten what the number is.  
7 But I'll try to find it and I'll get it for you.

8 HENNIGAN: There was another comment here on  
9 3.2, the type of gage we're using, they suggested a Cady  
10 Gage Model DW-1 and the Ames gage.

11 that  
12 Also on 3.2 they suggested/their method of measuring  
13 electrolyte absorption using a Kubelkaglas be instituted  
14 for weighing samples before and after immersion in electro-  
15 lyte. I don't know if you understand what this is. It's  
16 a beaker that has a long tube on it that is calibrated like  
17 a buret. And the electrolyte is put in the tube, and the  
18 sample is put in the beaker. And you tip it, let it soak  
19 for a certain length of time, and then you tip it back. And  
20 then you measure the amount of electrolyte for the second  
21 time and you find out how much was absorbed by the difference.  
22 It was kind of an invention by the company I think.

23 3.3 is separator resistance.

24 The comment was this test currently not performed  
25 at the company. Sufficient data would have to be accumulated  
to determine the target specification.

1 Are there any comments on the method they use for  
rms 55 2 resistance measurements?

3 (No response.)

4 And 3.4, separator wetability. This test un-  
5 acceptable from a separator manufacturer standpoint. Must  
6 have in-house wetability test while separator is being  
7 manufactured.

8 I don't quite understand that comment.

9 3.5 Tensile strength. They have suggested  
10 Federal Test Method 5102 of Federal Test No. 191 be used in-  
11 stead of the reference test.

12 This again, this test 191, applies to textile  
13 materials. The test presently being used is a jawbone(?)  
14 is cut and put into a regular tensile machine and pulled.  
15 I couldn't find this spec 191. It is on order.

16 3.6, Extractable Organic Content.

17 Does anyone have any comments on that paragraph?  
18 Does anybody have any comments on the solids(?) that are  
19 being used?

20 NIETZEL: We have a comment here that extraction  
21 using methanol will remove some inorganics such as zinc  
22 chloride which would be which would be counted as an organic  
23 constituent using this method and should be subtracted out.  
24 You would have to do a little talking I think on some of  
25 the analytical approaches here. We have to do something

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1 analytical. And I think we're going to have to get down to  
2 some nitty gritty on just how to attack this.

3 On methanol alone we'll have to now describe the  
4 purity and water content of the methanol and just how dry  
5 it is, so maybe this will start to develop as the morning  
6 progresses. I hope so.

7 HENNIGAN: Thank you.

8 3.7, Inorganic Content.

9 One of the comments is the target spec of 0.25  
10 percent is too low. Typical data is currently one percent.  
11 They suggest a target of .75 percent.

12 There is another comment. Ignition of the  
13 residue will volatilize certain inorganics, for instance  
14 zinc oxide.

15 Are there any comments on 3.7. Do you remember  
16 the numbers we are getting on that? Steve? They're higher  
17 than one percent I believe.

18 GASTON: Gaston from Grumman.

19 On the percent inorganic residue, I have numbers  
20 for Pellon ranging from .111 to .170.

21 HENNIGAN: So, there wasn't any spec.

22 3.8, Discoloration in Electrolyte.

23 Does anyone have any comment on that paragraph?

24 (No response.)

25 The reference ~~there~~ is a Munsell color standard

1 which I've used before, and it seems to be quite a good  
2 color standard.

3 GASTON: I would like to correct that statement.  
4 The percent ash was from .44 to .76, so it is higher than  
5 the specification had specified. I had the water extract  
6 before. So, it is somewhat higher than the target specifi-  
7 cation.

8 NIETZEL: What was the ignition temperature  
9 there, please.

10 GASTON: I'm trying to find it.

11 HENNIGAN: This is probably a good point, and we  
12 should specify a temperature.

13 GASTON: That's a good point. I don't see it  
14 here at the moment. It is not stated in this report. I will  
15 have to find out.

16 HENNIGAN: Thank you.

17 Paragraph 3.9, Thickness Variation.

18 Jerry, go ahead.

19 HALPERT: On the thickness variation I was in-  
20 formed by one of the separator people that were here  
21 earlier this morning that the beginning and the end of every  
22 roll is quite a different than what would be expected to be  
23 a continuous run and that it is recommended that we at  
24 least go back in the run on the order of five to ten yards  
25 before taking the first sample and before the end cut off

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1 the last five or ten yards before taking the last one.

2 FLEISCHER: Does that mean you should throw the  
3 first and last five yards?

4 HALPERT: Yes. That's what he said. His comment  
5 was that the calender which may or may not be used -- if it  
6 is used, the calender is released to some extent at the  
7 beginning of the run and then is set while the run is  
8 started for set up and is removed toward the end of the run  
9 when it is being completed, so that the thickness at the  
10 beginnin and ends might be significantly different than  
11 what might be the thickness in the middle.

12 FLEISCHER: Well, I think he shouldn't deliver  
13 the first five yards.

14 NIETZEL: Jerry, we have observed that ourselves.  
15 And I think part of the problems on incoming inspection is  
16 to make sure that the sample being inspected does repre-  
17 sent the product that you're going to use.

18 HENNIGAN: There is a comment here. In order to  
19 take thickness measurements on samples from the beginning,  
20 middle and end of a slitted roll, this must be an in-  
21 process test.

22 What he meant by this was the battery manufacturer  
23 should do it while he is processing the separator. Oscar?

24 NIETZEL: If that is the case, will he accept our  
25 rejection then?



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1 HENNIGAN: You will have to ask him.

2 NIETZEL: That's a problem.

3 HENNIGAN: Yes, it is. Was there another comment?

4 HERZLICH: I was going to make the same comment.

5 HENNIGAN: All right. Thank you.

6 Materials Used in Cell Formation, paragraph 3.10.

7 There is a comment here. We do not believe that  
8 the requirements for the formation separator of  
9 paragraph 3.2, which refers to the absorption, retention and  
10 porosity, 3.4.2 which refers to wetability and 3.5 which  
11 refers to tensile strength, are technically justified.  
12 This separator is not used in the finished cell. The tests  
13 outlined in 3.6 and 3.7 may be of interest since they do  
14 determine if any contaminants are introduced in the formation.

15 Are there any further comments on that paragraph?

16 Oscar.

17 NIETZEL: I'd like to make a comment on the comment,  
18 please. One way to get into trouble is to have available  
19 the potential for trouble. And that's what this comment  
20 allows. It is very difficult to have control in your  
21 processing and in your material handling, if you're going to  
22 allow within an area a certain batch that has one spec and  
23 another batch that has another spec. Murphy's law will  
24 strike. It has to strike. And it states that if it can  
25 happen, it will happen. And that's a fact. So, I do not

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1 like that comment. You just have a certain grade in house  
2 and that's what you should be using.

3 HENNIGAN: Thank you.

4 Any more comments on 3.10?

5 (No response.)

6 3.11, Separator Material Used in Production Cells.

7 There was one comment that this paragraph is totally  
8 impractical on a separator manufactured on commercial  
9 equipment.

10 Well, I asked them about that and they said well  
11 this was up to the battery manufacturers to check it.

12 CARR: In direct reference to that comment I would  
13 like to see something in the specification to the effect  
14 that where the inspection is done there are three distinct  
15 areas here. We have the manufacturing inspection, maybe  
16 actually four areas, manufacturing inspection, their accept-  
17 ance of the material, then our receiving inspection of the  
18 material and then again any tests that are done on individual  
19 pieces of separator as opposed to the roll. We buy the  
20 material as a roll. And then we cut it to size. Either in  
21 pieces or in a strip. And I would like to see some break-  
22 down of how we would go about inspecting.

23 HALPERT: Good point.

24 RICHARDSON: On 3.11 here, I would think, Pete --  
25 or Earl rather -- that you'd want at receiving when you buy

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1 the material from Pellon or wherever it is, that you'd  
2 probably want to run your 100 percent possibly on the  
3 whole roll. But then if you put it in storage and it sits  
4 around a while, and then you to ahead and cut the Pellon  
5 up to a given size to fit a given size plate, I think you'd  
6 want to run another visual check to see if you hadn't picked  
7 up any extraneous material due to the handling and cutting  
8 of the Pellon in the processing of it. So, I think you'd  
9 want to run another visual of some sort by the inspection  
10 or by the operator who is going to put the separator on the  
11 plates.

12 CARR: I agree completely, John. There is another  
13 problem and that is that we have many more than one type of  
14 separator in the house, and again we're talking about Murphy's  
15 law.

16 FLEISCHER: That reminded me of what happened at  
17 East Hampton on one occasion with woven nylon cloth. We  
18 received it in rolls and sent it out to be slit, and our  
19 cells foamed and foamed and we couldn't make cells. So when  
20 we analyzed the problem and went through the whole thing we  
21 discovered that the \_\_\_\_\_ mill used an anti-static agent  
22 on their nylon bobbins over which the material rolled. And  
23 they introduced the anti-static agent which was also a good  
24 foaming agent. So, you can have things happen on the way  
25 to cutting up nylon depending on -- or your separator --

1 depending on who does it and what care is taken.

2 HENNIGAN: We do have in our data sheet, it  
rms 62 3 goes along with the separator data sheet, not to use an  
4 anti-static agent. We've heard about that whole problem.

5 Bill?

6 BILLERBECK: I think probably one omission is a  
7 specification on storage of the material prior to its  
8 use here. The gentleman from Marshall brought out that  
9 there is a real possibility for contamination during the  
10 storage period.

11 STEINHAUER: Steinhauer, Hughes.

12 In paragraph 3.0 I wonder if we shouldn't use the  
13 "filtered", non-woven could apply to a membrane type of  
14 material.

15 HALPERT: We have a lot of tests here. One of the  
16 tests that is not included is air permeability, and I under-  
17 stand that our Canadian friends have used this as a criterion  
18 and I wonder if Dr. King might say a couple of words about  
19 the/<sup>air</sup>permeability of separators as a test for control.

20 KING: I think the best way to describe our  
21 permeability requirements is to read from the specification  
22 S-615-P-17 which was issued by Goddard SpaceFlight Center.

23 It states, "The separator material shall be a  
24 non-woven polypropylene material free from flaws or other  
25 imperfections. The air permeability of the installed separator

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1 subject of particles in the separator was discussed, and  
2 there has been some feedback that at one time or another  
3 the separator has been found on incoming inspection with  
4 metallic particles in the separator.

5 This type of think getting into a cell could be  
6 detrimental. I might suggest some type of test along the  
7 lines of screening for metallic particles that are not  
8 necessarily visible to the eye when you look at the separator  
9 on a visual test. We might look towards the people making  
10 capacitors, because they have also had problems, dielectrics  
11 coming in with metallic particles that would lead to high  
12 failure rates in capacitors.

13 I think this is an area we should be concerned with.

14 HENNIGAN: Are there any more comments on the  
15 separator?

16 (No response.)

17 I'll turn the meeting over to you, Jerry.

18 Oh, I'm sorry. We've got a couple.

19 CARR: Just in reference to 3.11. In addition to  
20 particles in the separator, it is also possible to have  
21 areas that have holes in them, so the 100 percent inspection  
22 of separator material appears to be required, 100 percent  
23 inspection at the assembly separation level where you do  
24 the separating of the cell.

25 NIETZEL: We are now going to leave the spec. We

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1 made a comment earlier here on this Hoffman degradation  
2 reaction. I didn't hear anything off the floor about it.  
3 Maybe I don't believe it, but one of the problems we're  
4 concerned with here is chloride ion concentration, and I  
5 don't see that here on the spec. I wonder if anyone else is  
6 concerned about it. And if so, how would they like to set  
7 up analytical procedures to determine what it is.

8 HENNIGAN: Well, in 3.7 we're supposed to determine  
9 the amount of chloride.

10 NEITZEL: What about spec limits?

11 HENNIGAN: We don't know what it should be, but  
12 some of the numbers are running rather high.

13 NIETZEL: Yes, they are.

14 HENNIGAN: Point nine percent.

15 NIETZEL: Nine thousand parts per million, right.

16 CARR: One of our problems it seems that we  
17 don't know all the results of the different impurities, but  
18 it appears that this one is a bad, so I think some real  
19 concern ought to be given here.

20 NIETZEL: I think another problem is if chloride  
21 ion exists you know there has to be usually some metallic  
22 constituent with it. It doesn't appear to be sodium ion.  
23 I think it's zinc, because it's an activating agent. And  
24 that's why some of our concern in here for solubility of  
25 zinc, the zinc chloride, in methanol also the ability to

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1 drive off the zinc when we're looking at firing for an  
2 oxide residue. So we'd just like to throw this out for  
3 comments please.

4 HENNIGAN: Does anybody have any comment from  
5 the zinc chloride content.

6 STEMMLE: Stemmler, Goddard.

7 In our labs there is some work going on with the  
8 X-ray machine for using X-ray fluorescence I believe,  
9 determining the concentration of chloride and zinc, and  
10 apparently both of these are present in about the same  
11 amount on the Pellon. The X-ray is one way of doing it.

12 HENNIGAN: Thank you for your comments. And  
13 I'll turn the meeting over to Jerry Halpert.

14 HALPERT: The next section dealing with Section  
15 8, Production Cell Acceptance Tests, will be chaired by  
16 Will Scott.

17 SCOTT: Section 8 is concerning acceptance tests  
18 on completed cells. The first submitted comments that I  
19 have are related to Section 8.1.2. I don't have any before  
20 that. Are there others. I don't know whether I have a  
21 complete list or not.

22 Okay, the first comment is still regarding  
23 8.1.2. But I see that it really relates to the entire  
24 set of requirements.

25 If there are no other -- there isn't really much

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1 to talk about before that section anyhow. So, the comment  
2 is temperature tolerance difficult to maintain. Discharge  
3 to 1.0 volts difficult to control. Seventeen-hour charge  
4 is costly. Shock and vibration not necessary. X-ray of  
5 minimal value. This comment is from Thierfelder. Would  
6 you like to say anything further.

7 THIERFELDER: I think the temperature limits were  
8 plus or minus 2°F. Yes. Well, it has been my experience  
9 that this is beyond the capability to maintain in a regular  
10 test facility.

11 SCOTT: Excuse me, are you referring to the  
12 numbers in section 8.4 and 8.5.

13 THIERFELDER: That's right.

14 SCOTT: And 8.6. Those three, because I see  
15 they run all the way -- plus or minus 2° runs all the way  
16 through here.

17 THIERFELDER: And on many programs we start out with  
18 numbers like this, and before the program is very far  
19 downstream we're saying like plus or minus 3°C which is  
20 then quite a bit beyond this.

21 The other comment about the discharging of cells  
22 down to 1.00 volts, the same thing there, we have tried  
23 this and found that when the cells get below say 1.1 or  
24 even 1.15, it may take 20 or 30 seconds before they go  
25 down to zero volts and into reverse. So, we have limited



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1 testing down to 115 to prevent this, and we've even had  
2 very sophisticated equipment. We automatically scan through  
3 the cells and scan through anywhere from 50 to 100 cells  
4 in less than a minute. And you scan through once, and the  
5 cells are up above 115, and on the next scan a minute  
6 later the cells have reversed. And we've had this happen  
7 on several occasions, so we do not discharge the cells  
8 below the 115, minimum voltage.

9 What were some of the other things?

10 SCOTT: Seventeen-hour charge.

11 THIERFELDER: Well, this is just a matter of  
12 time. I mean if you can charge the cells in eight hours,  
13 why take 17 hours. And I think I made a comment about vibration  
14 and shock. Well, on a hundred percent basis we have never  
15 done shock, and we did vibration for some years. And on  
16 the prismatic cells, we looked back over the data and found  
17 we had no failures in vibration in over -- I don't know  
18 what the number was, but it was many, many hundreds of  
19 cells. And then we stopped vibrating on the production basis.

20 On the X-ray, we also on the earlier Nimbus  
21 programs, Relay programs, we X-rayed all the cells in three  
22 different directions looking for everything from weld leaks  
23 to what we could find. And I personally spent many, many  
24 hours examining X-rays and finally the only thing we did  
25 find them useful for was on the spirally-wound cells, the

rms 69

1 round cells, and it did show up telescoping of the spiral.  
2 Other than that we found it really of no use, and we  
3 stopped X-raying because we were spending time and effort  
4 and not coming up with any results. And of course in some  
5 cases where cells did fail, the question came up -- go back  
6 to the X-ray and find out what the X-ray will show. And in  
7 no case did it actually give any information that was useful  
8 in the failure analysis.

9 RICHARDSON: Richardson, Marshall.

10 I've got several things here, one is I notice  
11 you have this organized in 8, 2, 3, 4, 5, like examination,  
12 your leak test, your capacity. Is this to suggest a  
13 suggested acceptance test sequence, or did this just happen  
14 the way that when the sections were entered in here, it  
15 happens that's the way they fell in place, or is there  
16 any rationale for putting them in that order you have them  
17 in?

18 SCOTT: I might comment on that. I don't believe  
19 that the order in which they appear is necessarily intended  
20 to indicate the best order or any specific order. It may.  
21 However, I do believe there is probably a preferable order.  
22 And possibly that order should be indicated in some  
23 separate paragraph ultimately.

24 RICHARDSON: Very good. Next on the high temper-  
25 ature capacity and the low temperature capacity tests you

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1 spell out, for example, for high you show maintain at 90  
2 plus or minus 2. Well, see, our requirements for our  
3 ni-cad cells, the high temperature may not be 90°. It might  
4 be 80 or something like this. And likewise on the low  
5 temperature side, we may have a different low temperature  
6 requirement for the operation of our cells, so therefore  
7 maybe this ought to be left open to the user, instead of  
8 spelling out a given temperature which may fit your require-  
9 ments in this case.

10 In addition, in the vibration section I don't  
11 think it is a good idea to spell out given vibration  
12 requirements, because the ni-cad cells we're going to use  
13 in ATM and Airlock module, this vibration criteria would  
14 not apply to the acceptance levels that we would use in  
15 vibration of the cells or the batteries themselves, so  
16 here again a suggestion would be that vibration criteria  
17 ought to be open to the using agency which you could spell  
18 out for a given use. Because in addition a four-ampere-  
19 hour cell would have different characteristics than a  
20 33-ampere-hour cell under vibration. And some cells maybe  
21 due to internal structural differences here again would  
22 react different under sinusoidal and random.

23 BILLERBECK: Billerbeck, Comsat.

24 I'd like to comment on several of these. I think  
25 the intention here was to show some typical environments

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1 rather than the detailed one, since it is a model specifi-  
2 cation, why indeed those things certainly open to the user  
3 to specify.

4 On the temperatures there was some feeling in  
5 the committee that there is a need to have some temperature  
6 and charge rate limits that are as universal as possible  
7 so that one can relate data taken from one program to data  
8 taken from another. And that's a real problem because  
9 you really have some conflicting requirements there. You  
10 would like to have the charge and discharge measurements  
11 so that you could relate between programs, but at the  
12 same time you want to know specifically what's it going  
13 to do in my program. I think that is something to be  
14 resolved.

15 FORD: Ford, NASA Goddard.

16 I don't think this is to be implied that these are  
17 all the tests that will be conducted on these cells. The  
18 implication here, as Billerbeck has indicated, is a set of  
19 standard conditions that would be applicable to all cells,  
20 and consequently to all manufacturers.

21 The point I want to make is this is not written  
22 to accommodate any specific program or any specific project?

23 RICHARDSON: But generally when you run acceptance  
24 testing it's for a given use in your program. If you have  
25 a high temperature requirement of 100°F, you want to test the

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1 cell at 100. You don't want to test it at 90, because  
2 the application is not at 90. And likewise if you're going  
3 to operate it at -15, here again, minus 15 below zero or  
4 something like this, I don't think you want to operate --  
5 you're talking about 32 or something that you have in the  
6 spec.

7 FORD: I agree with what you're saying, but  
8 I think what is implied here is that before you ever  
9 receive your cell to go through your specification, each  
10 manufacturer conduct his own tests, prior to running your  
11 tests. And it would be idealistic that they would be a  
12 comparison of this data, not only within a manufacturer  
13 from year to year but across the board throughout all  
14 cells you may possibly use from other sources.

15 RICHARDSON: What are you trying to say then  
16 that we run two acceptance tests, one at 90 to get a  
17 baseline for data and then run another high temperature.

18 FORD: That is currently being done in most cases  
19 today.

20 BILLERBECK: I think it actually turns out that in  
21 many cases these conditions are acceptable, but in some cases  
22 there may be in addition some special requirements for a  
23 particular program, high rate discharge, different temperature  
24 limits and so on.

25 So, one approach is to do these as a standard

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1 set of tests and then add any special requirements.

2 SULKES: Sulkes, U.S. Army Electronics Command.

3 In your temperature limits you call out the cell  
4 case temperature shall be controlled. And this would almost  
5 indicate that the cells are something like a water bath.  
6 And I just want to find out if that is the intent of the  
7 specification writers.

8 SCOTT: I'd like to comment on that. Aside from  
9 the question of exactly how you do it, there is a strong  
10 interaction between the temperature of a cell and the  
11 capacity that you will measure under any given set of  
12 conditions.

13 In the past this temperature has not been very  
14 carefully controlled. And as a result there is usually a  
15 considerable dispersion or uncertainty as to what the  
16 real capacity is to any tight set of limits. And I think  
17 if we are going to improve our specification of capacity  
18 we must improve the control of temperature, and I don't  
19 think this is quite the proper place to get into a dis-  
20 cussion of exactly how we're going to do it.

21 SULKES: I think if you do spell it out this  
22 way, then you do have to give them the method, because  
23 you still run into the same problem. If you don't specify  
24 a method that everybody can use, you'll get the same  
25 variations. A water bath or something like that is a valid

1 method if this is what you want to use.

2 LANDSMAN: Landsman, MIT.

3 On this shake, we prefer to shake the cells more  
4 or less in the mountings that they will see in flight. And  
5 I would suspect it would be better not to have the battery  
6 manufacturer shake them, leave that up to the user, just  
7 let the battery manufacturer do the three -- the capacity  
8 tests at the three temperatures for the records, and then  
9 let the user shake and check after the shake.

10 SCOTT: May I comment? And then we'll have others.  
11 I feel that in every case the customer, the user, will have  
12 the option of indicating which of these tests are done at  
13 the suppliers and which are not and which he does. I don't  
14 think there's any implication here as to exactly who is  
15 going to do these tests and where. I guess this is subject  
16 to individual decision on each procurement.

17 RAMPEL: Rampel, General Electric.

18 8.6, Capacity at low temperature. From the  
19 standpoint of capacity the input duration of 30 hours  
20 may be sufficient, there's no question about that. But I  
21 think the voltage limit is a little high, 156. I would  
22 also like to recommend for consideration that some kind of  
23 overcharging of greater duration than 30 hours be incor-  
24 porated at low temperature. We have on occasion found that  
25 in charging cells at 32°F for, oh, say, 48 hours and you

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1 can continue on and eventually exceed a given voltage  
2 limit. And I consider capacity at low temperature to be a  
3 very important test.

4 HERZLICH: Herzlich, Sonotone.

5 It was mentioned here that one of the ways  
6 to perform the shock and vibration tests was to redo the  
7 test that the user wants and then repeat the test according  
8 to the specification.

9 I asked a question, isn't it reasonable to  
10 expect that the order in which you do the two tests is  
11 important. And by that I mean one shock test or one  
12 vibration test will influence the results of the second.  
13 And the second question I ask is: Having done two such  
14 tests, what can you really say about the cells?

15 SULKES: One basic question of philosophy in  
16 all these capacity tests -- and they are supposed acceptance  
17 or rejection tests -- is that there is no level set on  
18 how high cells can go. In other words, to achieve a  
19 uniform balance. What sigma limits would you want to set?  
20 Or should they be set? And I feel if you have a 34 ampere  
21 hour cell that they can spread from 34 up to 40 or 42.  
22 This is not the kind of cells you really want to use for  
23 a balanced battery, and perhaps you should have sigma limits  
24 on these things.

25 MAINS: NAD, Crane.



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1 I think one consideration that should be made  
2 is one the shock and vibration tests that you might possibly  
3 want to operate the cells to see if there is any effect  
4 during this period of time rather than looking at it after-  
5 ward. Something might happen or might shift inside the  
6 cells that would be detectable during the shock or the  
7 vibration test that would not be exhibited after the test  
8 is completed.

9 GROSS: We all know that the effects of the  
10 initial cycling on cells changes the cells a little bit at  
11 the beginning of life. And it will make a difference as to  
12 whether we run these tests right when the cell is fresh  
13 or if it has a few cycles on it. I would expect a minimum  
14 of five to ten cycles would be required in order to obtain  
15 consistent results.

16 STROUP: Stroup of Goddard. In general, I would  
17 like to say something regarding our experience at Goddard  
18 in building a satellite battery, running the acceptance  
19 tests and doing much of the same things and looking at what  
20 is being proposed here in the specification. We have  
21 found that the numbers for end of charge voltage as in  
22 8.4, in determining capacity to be completely unacceptable.  
23 I would say anything over 145 in our flight programs would  
24 be grounds for rejection of the cell.

25 I don't know where the 151 comes from. It may be

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1 a valid number, but we haven't found it so. The overcharge  
2 test under 8.8 calls out a voltage of 1.48 volts. This  
3 too is at the same rate of C/10 which is a rather moderate  
4 rate in our experience. It seems to be a rate that is  
5 common to most manufacturers, both as to space cells and  
6 as to commercial cells as a recommended rate for charging  
7 the cell in practice.  
8

9 Maybe this makes it a good rate to use, since  
10 we have lots of data at the C/10 rate, it's a good reference  
11 point. This would be an argument for using it rather than  
12 a different rate which was suggested by some of our other  
13 people here today.

14 " The 148 volts in 8.8 definitely by our experience  
15 on flight cells is at least 3/100ths of a volt higher than  
16 the maximum level that I would set for a flight battery.  
17 And from an electro-chemical consideration of gas gener-  
18 ation the charge state of the battery at that particular  
19 time I think we all must agree not to be too nitpicking  
20 on this, and I mean it as a strictly scientific fact, that  
21 we generally must agree that about 147 from our experience  
22 is as high as we dare go on an overcharge level at that  
23 particular temperature and condition.

24 SCOTT: I have a comment on the comment there.

25 I am wondering whether any of the manufacturers would care  
to comment on whether or not if we indeed are going to

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1 impose some strict voltage limits on charging in the final  
2 cell whether those requirements are going to have to be  
3 fed back into the process somewhere to actually control the  
4 manufacturing of the plates in some way.

5 CARR: Carr of Eagle-Picher.

6 Dr. Scott, in response to that, there are ways  
7 of changing the end of charge voltage. And in fact we have  
8 designed batteries deliberately with what we call a tail-up.  
9 This is to work on different types or a type of charge  
10 control, and it works quite successfully.

11 So, let's say we know how to make them to do  
12 this and we know how to make them to do higher voltages  
13 at the end of charge, higher controlled voltages at the  
14 end of charge, so that we just want to enter this into the  
15 minutes to be considered.

16 SCOTT: I'm informed by the chairman that we should  
17 break off at this time. So, I will turn the meeting back  
18 to Jerry. And he will tell you what is next.

19 HALPERT: As the next item, since we were a little  
20 to  
21 early getting over/the cafeteria yesterday, I've arranged  
22 for a 10 to 15 minute tour of our operations center.  
23 And Mr. Kelly is going to lead us on over. It is within  
24 this building area. It will take about 10 or 15 minutes  
25 and then we can walk on over to the cafeteria at the end.

Secondly, if you are interested in the specs on

1 silver cadmium, to get a chance to look it over before  
2 tomorrow, these are available at the front of the room  
3 here, and you can pick one up.

4 So, at this particular point, let's break and we'll  
5 meet back here after the tour and after lunch at about  
6 1:15.

7 (Whereupon, at 12:18 p.m., the conference was  
8 adjourned for lunch to reconvene at 1:15 p.m.)  
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AFTERNOON SESSION

(1:40 p.m.)

HALPERT: Gentlemen, may we take our seats, and we'll try to get started again.

I just want to make note of one item. We've decided for tomorrow morning's meeting that we will continue in here rather than in Building 22. And if any of you know people who are going to attend, or for yourselves, report back here. And we'll get a message out to the guards to transfer anybody who is scheduled to go to Building 22 to come in here instead.

At this point I would like to turn the meeting back to -- excuse me?

BILLERBECK: Excuse me, Jerry. Then tomorrow definitely will be on the silver?

HALPERT: Right. We hope to finish the nickel-cad tonight even though it takes until midnight.

How many people are planning to attend tomorrow -- can I see some hands, to get an idea?

(Show of hands.)

Okay. I'll turn the meeting back to Will Scott.

SCOTT: I would like to proceed, for the moment, to go through in numerical fashion the formal comments to section 8, and then we -- depending upon the time and all -- may want to return to an open discussion afterwards.

1 First of all, I presume possibly from the results  
2 of the earlier session, that there may not be any more  
3 comments specifically directed to the content of section  
4 8.1.2. Aside from the actual requirements as called out in  
5 the following pages.

6 Are there any comments on section 8.2, Examination  
7 of Product?

8 (No response.)

9 I have some comments on section 8.3. Comment:

10 "We take exception to the electrolyte leakage  
11 test being performed using Cresol Red solution. It  
12 is our experience that this indicator gives spurious  
13 indications, and we would prefer the use of phenol-  
14 phthalein as the indicator."

15 Another comment:

16 "This test is best performed during or after the  
17 cell has undergone an increase in internal cell pressure.  
18 Thus, this test should be performed while the cell is  
19 in the overcharged mode, or has been recently removed  
20 from charge and still has a residual pressure. If  
21 the cell does not build up a positive pressure while  
22 ch charging at the C over 20 rate, the charging rate should  
23 be adjusted to produce an internal cell pressure greater  
24 than zero psi g."

25 Are there other comments from the floor on section

1 8.3?

2 THIERFELDER: Thierfelder, G. E. Space Systems.

3 If the order which is listed here is the order in which the  
4 tests are to be run, I agree with the last comment, because  
5 the electrolyte leak test should be run after the cells have  
6 been on overcharge, and if not immediately during overcharge,  
7 at least following the discharge after that charge, because  
8 the leakage will remain there.

9 If it's a test for electrolyte leakage, the first  
10 thing you do when you get the cells -- or the first thing  
11 after you finish the cells, I don't think is too meaningful.  
12 It would have to be repeated later anyway.

13 BOGNER: Bogner, JPL. Perhaps the place to do it  
14 is 8.8.

15 BILLERBECK: 8.15 covers this again.

16 SCOTT: Yes. Mr. Billerbeck points out that section  
17 8.15 calls for a second electrolyte leak test. I think the  
18 point is well made that one should try to conduct this test  
19 at least at some point while the cell is presumably under  
20 pressure. I'm not exactly sure how you're supposed to know  
21 that it is, or how much pressure, unless you have gauges  
22 on the cell.

23 But certainly the presence of pressure should increase  
24 the sensitivity of the test.

25 Comments on section 8.4:

1 "It is extremely difficult to maintain a 75 plus  
2 or minus 2 degrees F. during a capacity test without  
3 using the temperature controlled bath. The correct  
4 tolerances should be determined for an open bench type  
5 of test which is most practical when dealing with a  
6 large number of cells. Convection cooling would be  
7 added to the open bench test so that temperature  
8 excursions are kept to a minimum.'

9 Additional comment -- a suggestion for an addition  
10 to this paragraph:

11 "The variation in capacity within the lot of cells  
12 should not exceed plus or minus 7 percent."

13 Further comment.

14 "Also, the capacity as specified has an open ended  
15 tolerance. A maximum capacity should also be specified,  
16 which may vary depending upon the duty cycle the cells  
17 will have to undergo. This maximum capacity should be  
18 negotiated between the manufacturer and user."

19 It doesn't appear that I have any more formal  
20 comment. Is there any from the floor?

21 NIETZEL: Yes. I wish that we, as a group, would  
22 start to look at this paragraph. It seems to me that there  
23 is no necessity for a meeting here these last two days unless  
24 we do look at the capacity of a group of cells, and accept what  
25 we will set as a spec limit on cell capacity. We can have the



1 best control in the systems, and if we end up with a product  
2 whose one sigma standard deviation is unacceptable, then  
3 we've gone noplacel. We may by serendipity not know what we're  
4 doing, and yet have a product that does have a very tight  
5 tolerance. This is not beyond the realm of possibility.

6 We should, at this meeting, decide what will we  
7 accept for the capacity variation in a lot of cells, and  
8 we're suggesting at the one sigma limit, 2.3 percent.

9 I'd like to throw this open for comment.

10 STROUP: Stroup, of Goddard. One time we did have  
11 occasion to specify something just about of that order. The  
12 gentleman that had the problem -- two of them -- I believe  
13 one was Lou Belove, but they managed to achieve this range of  
14 plus or minus 2-1/2 percent on capacity.

15 But it wasn't without a considerable amount of  
16 effort. I don't know whether they'd be willing to address  
17 this in more detail to anyone or not. They did do it for us,  
18 and did a very nice job.

19 BELOVE: Belove, Sonotone. The cells that Gene  
20 Stroup was referring to were done by proceeding after a fashion  
21 that we have been discussing here the last two days -- that is,  
22 testing every plate and choosing those plates that were bound  
23 to give us close tolerances in capacity.

24 CASSOTTA: Cassotta, Bell Labs. We tend to -- I  
would very much support Mr. Nietzel in his plus or minus 2.3

1 percent, because this represents a pretty good lot.

2           However, I am asking a question. He said one sigma.  
3 Now, if you handle this with normal statistical methods, you  
4 usually accept everything within the three sigma limits, and  
5 we're going to be right back to 7 or 7-1/2 percent.

6           NIETZEL: Do you want another number then, Tom?

7           CASSOTTA: I would like to see that 2-1/2 plus or  
8 minus absolute.

9           SULKES: Sulkes, U. S. Army Electronics Command.  
10 There was some work done a while ago by Wagner at Yardley  
11 Electric on an Air Force contract to develop a nickel-cad and  
12 silver-cad cells with, I believe, a plus or minus one percent.  
13 And for the silcad this was achieved, and it was fairly  
14 closely achieved for the nickel-cad. And basically this  
15 involved individual plate testing and so on.

16           But it could be done, and it was done.

17           THIERFELDER: Thierfelder, G. E. Space Systems.  
18 I have some data here of actual numbers on a particular  
19 program. And this is a program using 419 cells.

20           On the various batches the capacity plus or minus  
21 variations were anywhere from 1.9 to 7.0 percent from the  
22 average.

23           And of course that -- and the average of the total  
24 was 5.0 percent, for the 419 cells. The three sigma limits  
25 would be 15.1 percent.

1 FLEISCHER: Thierfelder, will you tell us if that  
2 average is the rated capacity, or is that the actual determined--

3 THIERFELDER: These are variations from the actually  
4 tested capacity.

5 FLEISCHER: Now what was the rated capacity?

6 THIERFELDER: The rated capacity was 12 ampere hours.  
7 The actual average was 14.4.

8 FLEISCHER: Well which one are we talking about?

9 THIERFELDER: Well these are basic numbers on  
10 variations from an average.

11 FLEISCHER: I mean here, what do you understand that  
12 we're talking about here, in this 8.4? . . . shall equal  
13 or exceed the rated capacity. So we're talking about the  
14 actual here. All right.

15 SCOTT: I think there is a confusing use of words  
16 here at the end of this paragraph. The sequence, "rated  
17 capacity specified," I think needs to be worked over a little  
18 bit. Because rated capacity is usually a manufacturer's  
19 rating. Specified, I interpret this as specified by the  
20 user.

21 And so I'm not sure this is a compatible sentence  
22 right now. I think that whole business of rated versus actual  
23 is a bag of worms that is going to have to be resolved sooner  
24 or later. And I feel that really the only basis for talking  
25 about sigma limits and other control numbers must be on an

1 actual measured value, and not have anything to do with a  
2 nominal rating.

3 So that rated capacity thing may be confusing there.

4 HENNIGAN: I would like to make a comment on the  
5 silcad batteries. We found years ago if we just bought cells,  
6 so many, if we got within plus or minus ten percent we were  
7 doing good.

8 Now we're built according to the blue book here, the  
9 spec, we can hit plus or minus two percent, but we still reject  
10 about 10 percent of the cells that do that.

11 GREEN: Green, Martin. I'm looking at this para-  
12 graph, and I see the intent of your last sentence is to make  
13 sure that your cell has the capacity you bought.

14 Now we're talking about variations above the capacity  
15 of the cell, which in the case of the manufacturer for his  
16 usual pad you get 20 ampere hours, and the most that we have  
17 received at Martin have been in the neighborhood of 24 or 25.

18 This excursion I don't think is so important from  
19 the standpoint of the cells themselves, but I believe it's  
20 highly important when it comes to assembling them in a battery.  
21 And under this condition, I see nothing in the index at least  
22 that refers to the assembly of cells. It would appear to me  
23 that we could take, say, a dispersion of 7 percent and as long  
24 as we used the low percentage in one battery and the high  
25 in the other, we accomplish something in the form of a balance

1 between cells, which will give you much better action on  
2 charging and discharging characteristics.

3 While I'd like to see them as close as possible, I  
4 do believe that a little larger excursion doesn't hurt if you  
5 use a per cell selection. I see nothing about that in this  
6 test procedure, about giving information for cell matching or  
7 cell selection.

8 BOGNER: Bogner, JPL. I think we haven't expressed,  
9 here how we terminate the volt, or the discharge. We say at  
10 one volt per cell. And I think most of this is usually done  
11 manually. A light may come on or he may have an operator  
12 standing there watching a volt meter. And you can have quite  
13 a large error or spread, just from a person not being there  
14 right at the instant it hits one volt.

15 And also these are usually run in a series of cells --  
16 I don't know, 20 or 30 cells in a series -- and by the time a  
17 fellow takes that cell and removes the clip and takes it out  
18 of the circuit, by the time you get down to the last cell, it's  
19 got a longer run time when it actually hasn't been operating.

20 So this test probably should be run with automatic  
21 equipment.

22 STEINHAUER: Steinhauer, Hughes. There are several  
23 statements that have been made that the only way the closely  
24 controlled plus or minus 2-1/2 percent on capacity range has  
25 been achieved is by inspection of individual plates. I'm

1 wondering if this is always necessary, or if by tightening the  
2 process it can be achieved without this 100 percent inspection,  
3 and if the people from TI would comment?

4 NIETZEL: Your process control parameters can be  
5 designed in such a way that when you make a group of cells,  
6 they will then fall into the specifications, without sorting  
7 as a function of assembling the cell packages.

8 Is this an answer? Is this the answer that you want?

9 STEINHAUER: I'm wondering if you're running a 100  
10 percent capacity test on individual plates, or if your process  
11 inherently can produce plates that are within closely controlled  
12 categories?

13 NIETZEL: If by "plate," you mean the pieces of plate  
14 that are inserted into the cell, we do not check that -- no.  
15 We will take impregnated plate, cut to dimensions, and make a  
16 cell. And then if you make 100 cells and put them on the  
17 boards, your standard deviations will be within the limits that  
18 you desire.

19 There is absolutely no checking of individual pieces  
20 of plate prior to cell assembly.

21 HALPERT: I want to ask, Oscar, when you talk about  
22 that one sigma, are you referring to taking only those cells  
23 that were within that one sigma -- 2.3 percent -- is that what  
24 you said?

NIETZEL: The standard deviation of a lot of cells

1 will be 2.3 percent. That's the total lot.

2 HALPERT: Well, that's not one sigma, then. That's  
3 three sigma.

4 NIETZEL: No, that's one sigma.

5 HALPERT: That's one sigma. Now you're only going  
6 to accept the cells in that one sigma range?

7 NIETZEL: I'm asking what you people want. What do  
8 you want?

9 HALPERT: Are you asking us here?

10 NIETZEL: Yes, because you're going to use them.  
11 What do you do when you finally put a group of cells together  
12 to make a battery? How tight do you select them? And why  
13 do you have to throw the rest of them away? Why don't y ou  
14 just buy the product to that spec?

15 SCOTT: I'd like to comment on that. First of all,  
16 I agree entirely that an upper limit should be imposed, in  
17 addition to a lower level on capacity.

18 I'm not quite sure that any or any one group can  
19 decide today on any individual number for what this dispersion  
20 in capacity should be. But I know that we have a great  
21 difficulty accommodating the spread like plus or minus 7 or 10  
22 percent in capacity into most spacecraft programs.

23 This becomes even more difficult when you get into  
24 the area of systems containing more than one battery in  
parallel, where the characteristics from battery to battery now

1 become critical.

2           And therefore, we must, I think -- at least I feel  
3 that if you're going to build systems in this way, and  
4 certainly some of these very large power systems that may be  
5 coming up for the space station and so forth, appear to  
6 absolutely require many parallel strings of cells, that the  
7 uniformity of characteristics of cells and batteries over a  
8 large number of cells have to be strictly controlled.

9           And I think this is going to demand a much tighter  
10 control on the capacity spread over periods of years of  
11 production -- not just a batch of 50, or a batch of 30 or a  
12 batch of 100.

13           And so I'm all for this approach. But I don't  
14 really know what those numbers should be. I think we probably  
15 have to look harder now at the procedures and requirements  
16 for cell matching, and translate those requirements back into  
17 the cell specification. And I don't think we've really done  
18 our homework on that yet.

19           So I don't really think we can hammer that out today,  
20 either.

21           FLEISCHER: I think it would be nice if the Bell  
22 Laboratory people would tell how they selected their cells  
23 for matching in the Telstar program. As I remember, it wasn't  
24 only capacity, but recharge voltages and various voltages. It  
25 is rather difficult to tell from the report exactly what the



1 criteria were that were combined. But they have already done  
2 this, and maybe their experience could help in settling what  
3 things ought to go in here.

4 CASSOTTA: As I recall, the parameters that we used  
5 at the time were end of charge voltage, for one. This was at  
6 room temperature, following a 16-hour charge at a C/10 rate.  
7 It was the end of charge voltage, following a 16-hour charge  
8 at the C/15 rate at 32 degrees F. It was the discharge  
9 capacity at room temperature following the charge I described,  
10 through a one ohm load, and a similar discharge capacity  
11 through a one ohm load at 32 degrees F.

12 We looked at the overcharge potentials at the end  
13 of -- and I'm not certain of this, this is the one that I'm  
14 kind of stabbing at. This was way back, Art, and I haven't  
15 look at those numbers recently. But I think two weeks was  
16 the period that we used.

17 We also made what we arbitrarily decided were  
18 internal resistance measurements, and self-discharge measure-  
19 ments. Then we took each of these parameters on the group  
20 that we had measured them on, and constructed distribution  
21 plots of each of these parameters.

22 And based on the distribution plots that were con-  
23 structed and the cells appearing within a band which we arbi-  
24 trarily selected, this is essentially how we went about it.

25 STROUP: We do very much the same thing. We put

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1 more weight on the -- in our flight batteries -- on the over-  
2 charged voltage that we do on the capacities. Capacity ranges  
3 in actual flight batteries have been plus or minus seven  
4 percent, perhaps, at the gross condition. The capacities don't  
5 seem to work too much against us in the actual operation of  
6 the battery.

7           The big problem is having overcharged voltages  
8 uniform between cells when you put them in the battery. So  
9 I would say that the overcharged voltage, from my experience,  
10 is by far the more important single item that you can look at  
11 when it comes to selecting cells to put into a space battery.  
12 And this is one reason why before I had commented on the stip-  
13 ulation of the 1.51 voltage at room temperature, and the 1.48  
14 overcharge voltage at room temperature.

15           Now I'd like to say just a little bit more about  
16 that. On the radio astronomy satellite Explorer battery which  
17 was built at Goddard, the mean overcharge voltage of that  
18 particular package was on the order of 1.41 at room temperature,  
19 1.41. And the spread was on the order of 1.40 to about 1.43 --  
20 over about 90 percent of the cells fell in that range. That's  
21 on overcharge.

22           FORD: One thing that has been overlooked in this  
23 testing is the fact that are you going to run most of these  
24 tests, electrical tests at least, still looking at the pressure  
25 characteristics of the cells. I think in too many cases this

1 one characteristic is let fall by the wayside, when in fact  
2 it becomes very important, particularly where you can observe  
3 over a period of several tests a trend in a cell to show stable  
4 pressures, or a cell to show continuously increasing pressure  
5 over several test sequences.

6 I don't think anywhere in this spec it is mentioned  
7 that the gain should be left on the cell throughout the elec-  
8 trical test. Granted, the mechanical test is something else.

9 But I don't think this information should be over-  
10 looked. It goes one step further, as was mentioned yesterday,  
11 that there is another consideration I think is important and  
12 we should begin to look at it very hard -- is the recombination  
13 rate of oxygen in the cells become a criterion also for cell  
14 selection.

15 SULKES: Sulkes, U. S. Army Electronics Command.  
16 One point that the gentleman from Bell brought up that would  
17 perhaps be quite a good test -- and I'd like to get some  
18 opinion on it -- would be a use of either a capacity loss on  
19 stand, or let's call it a charge efficiency test, where you  
20 perhaps only charge up to 90 percent of capacity, and then see  
21 what you get.

22 If this would be some sort of valid test of perhaps  
23 how much nitrate is in the cell, and what efficiencies they do  
24 have. This might be an important characteristic as well.

GROSS: Gross, Boeing. We mustn't lose sight of the

1 fact that there are two things that distinguish. One is the  
2 problem of getting good, uniform cells to begin with, and the  
3 second is the task of selecting from that group the best  
4 matching that we can.

5 Certainly you can get matched capacity to any speci-  
6 fication if you have a large enough sample. But to me, the  
7 important virtue in specifying close tolerances on capacity  
8 is that the cells will have the best chance of having been  
9 made in the uniform way, so that they will age in a uniform  
10 way. And they will behave pretty much together.

11 You certainly would not expect that if you have a  
12 very large variation of capacity and then select from that  
13 group the best cells, even though the capacity is the same,  
14 they certainly would not age the same.

15 THIERFELDER. Thierfelder from G.E. I think we're  
16 over-emphasizing this capacity measurement by quite a bit.  
17 I've found in actually going back over the results of life  
18 tests that there was no correlation between the life of a cell  
19 and the capacity of a cell when they were new. In fact, in an  
20 awful lot of cases the ones that had the best capacity were  
21 the ones that failed first.

22 And I found that there was much more sensitivity in  
23 a test when you cycle the cells -- for example, specifically,  
24 we cycled cells for 20 cycles to some given depth of discharge,  
25 and at the end of the 20 cycles, completely discharged the cells.

1 And what we then called the -- I forget the name -- the  
2 capacity from the end of the last cycling discharge down to  
3 1.5 volts, this could be correlated to some extent to the life  
4 of the cells. This was on the Nimbus program.

5 But to try to correlate life versus the original  
6 capacity, there was no correlation at all. And to think that  
7 by getting the highest capacity cells we're getting the best  
8 cells, I think this is very misleading.

9 SCOTT: I don't believe that I heard that we are  
10 striving for the maximum capacity. I agree with you that the  
11 highest capacity for a given size cell is not necessarily the  
12 most desirable thing to have. I think that a controlled  
13 capacity is more desirable.

14 And there is also a possible impact of extra high  
15 capacity, cell capacity, a possibly adverse interaction of that  
16 with excess negative capacity; because the higher the positive,  
17 presumably, possibly the lower the excess negative capacity is  
18 going to have to be.

19 So certainly I think that, again, there should be an  
20 upper limit as well as a lower limit on the capacity specifi-  
21 cation.

22 STEINHAUER: Steinhauer, Hughes. I'd like go on  
23 record as concurring with Dr. Scott's earlier comments on this  
24 subject.

25 We're putting into a spacecraft, on both the charge

1 control and on the discharge load sharing. Each spacecraft  
2 has its own characteristics. We may need closely matched end  
3 of charge or overcharge voltages, depending upon the charge  
4 control technique that is used. We may need extremely uniform  
5 discharge capacity, depending upon whether it's a single bus  
6 spacecraft or multiple bus, depending upon how these batteries  
7 may load-share.

8 Right now on two of the spacecraft that we have in  
9 progress we're using a battery cutoff voltage, or we design  
10 to a 117 or 115 volt per cell on a battery. But this is an  
11 average, to end of discharge.

12 We look to very closely matched cells to be able to  
13 do this on a battery basis. We don't want to have to sense  
14 individual cells.

15 So, all I'm saying is that this specification cannot  
16 state what would be required for each spacecraft or any in  
17 general. I think we have to come up with some general charac-  
18 terizing and classification of the cells that would be required  
19 overall. But these paragraphs are going to have to be amplified  
20 for each spacecraft application.

21 FORD: Ford, NASA Goddard. I'd like to make a  
22 further comment on that. In fact, it goes so far as to say  
23 that for every spacecraft application your cell selection  
24 criteria should necessarily be different.

25 For example, in synchronous orbit it is not uncommon

1 to see depths of discharges in excess of 40 percent, and  
2 even possibly in some cases up to 70 or 80 percent.

3 Certainly in this case cell matching in capacity  
4 becomes very important, as contrasted to a spacecraft in a  
5 200 nautical mile orbit, where you're only using 15 to 25  
6 percent of the capacity.

7 Another example is a situation where you may have  
8 low charge rates available, and your range of C/30 to C/40  
9 consistently, throughout the life, I don't think it really  
10 gains you much to match capacity at a C/10 charge rate, when  
11 throughout the life of the cell it's going to be C/30 with a  
12 40 charge rate.

13 So, to tie this specification into cell selection  
14 and cell matching, I think is out of the question. Because  
15 each application has to be considered in its own light, and  
16 the certain requirements that are associated with the applica-  
17 tion.

18 GASTON: Gaston, Grumman. I'd like to go back to  
19 Mr. Ford's earlier comment, and I certainly agree with him  
20 about the overcharge characteristics for the voltages are  
21 very important in cell selection. On the OAO batteries we have  
22 used a distribution curve with the various overcharge voltages  
23 at three different temperatures. And we also compared the  
24 pressures. And based on that we have selected the cells which  
25 were most closely matched. And I strongly believe in the

1 paragraph 8.8 in the overcharge test, that in addition to 75  
2 degree overcharge, a lower temperature overcharge should be  
3 added to see the recombination characteristics at lower  
4 temperatures.

5 SCOTT: Well maybe I'd like to take this five-second  
6 gap to get back on the track a little bit here. Maybe if we  
7 have time at the end we can come back to talk about some of  
8 these more philosophical questions.

9 I don't mean to say that they're of no importance,  
10 but I believe, as was earlier stated, the intent of this  
11 section was to provide some examples of generally applicable  
12 acceptance tests that might be useful in comparing cells  
13 made by a given process, regardless of what their end applica-  
14 tion was, and regardless of what the specific requirements  
15 for cell matching charge control and other characteristics  
16 for a given application may be, I'm not certain that there is  
17 any one set of completely acceptable, universally applicable  
18 acceptance tests.

19 But this is what we're exploring right now, and  
20 this is a first cut. Certainly these cannot be expected to  
21 be the substitute for actual, individual cell tests to design  
22 a battery for a specific application.

23 I have some formal comments on the combination of  
24 sections 8.5 and 8.6. Comment:

25 "The most practical method for testing a large



1 number of cells is in these cases a temperature  
2 chamber. Again, convection heat transfer is used and  
3 under these conditions a tolerance of plus or minus  
4 two degrees F. is insufficient. It is requested that  
5 the tolerance be opened up after determining what can  
6 be obtained."

7 Again, on 8.5 and 8.6:

8 "Both sections appear arbitrary in the selection  
9 of these test temperatures and current densities. If  
10 the end use of the cell requires operation at tempera-  
11 tures other than 75 degrees F., then the operating  
12 extremes should be the test temperatures. In this  
13 manner the cell operation at the duty cycle temperature  
14 is measured. Similar comments also apply to charge and  
15 discharge rates.

16 "Also, this test procedure will impact directly  
17 on cost and delivery of the product, since the manufactur-  
18 ing cycle is extended and additional labor is required."

19 Other comments?

20 FORD: Ford, NASA Goddard. I'd like to ask a  
21 question -- if there would be any response to it.

22 As standard procedure for the manufacturers' repre-  
23 sentatives here, does anyone normally run any tests at other  
24 temperature than room ambient? I'm not talking about the test  
25 specified by the customer -- I'm talking about of your own

1 choosing. Do you run tests at other temperatures, other than  
2 room ambient?

3 RAMPEL: Rampel, General Electric. Yes, we do. We  
4 run high and low temperature, in that order.

5 RUBIN: Rubin, T.I. In terms of normal in-process  
6 testing, as this specifies, we only test 100 percent -- to  
7 a 100 percent level at 75 degrees F.

8 SCOTT: Paragraph 8.7. Comment:

9 "Is there any significance to the 5C rate and does  
10 it reflect the maximum all cells have to perform at?"

11 Any further comment on that?

12 (No response.)

13 I may comment that in the light of the definition  
14 of what this was intended to do, I guess it may be obvious  
15 now that this was not intended to represent any specific  
16 usage, but only a number that is useful for characterizing  
17 the high current capability of the cell, and in a general  
18 manner, for comparative purposes.

19 FLEISCHER: Does this mean that the cell is to  
20 be discharged for 10 seconds at 5C, or that it has to be at  
21 one volt minimum for 10 seconds? I don't quite understand  
22 what this means.

23 BILLERBECK: I think it was intended to mean that  
24 after 10 seconds of discharge, that the voltage should remain  
25 above one volt. And I think this is typical -- that this

1 requirement stems from squib firing in the spacecraft.

2 BELOVE: Belove, Sonotone. As I recall the origin  
3 of this test, it started with some of our first cells. In  
4 the cylindrical cell, with a two-plate cell, at that time  
5 there was some difficulty with welding. We were never quite  
6 certain as to whether there was a weld established at the  
7 bottom of the cell. This has since been changed. But at  
8 that time we established a high-current, 10 second test. And  
9 we read the voltage after 10 seconds, and through that, estab-  
10 lished whether we had a weld or not. Because at the high  
11 rate you could usually determine the difference between a good  
12 and bad weld.

13 At this time we see no reason for it in our cells  
14 and I think in others too, because welding has been improved.  
15 But in the early days this is what it was used for.

16 FORD: Ford, NASA Goddard. This type of test is  
17 normally run as standard procedure on flight hardware after  
18 environmental tests.

19 SCOTT: Paragraph 8.8 -- is there some other  
20 question?

21 (No response.)

22 Comment on paragraph 8.8:

23 "Does this test reflect what is required of the  
24 cell during actual operation? It could interfere with a  
25 cell design where maximum electrolyte fill levels are

1 desired, and where the actual application does not require  
2 extended periods of overcharge. This type of test is best  
3 coordinated with a 'conformance to duty cycle' specification,  
4 and would include the extremes of operating conditions."

5 That's all the formal comments I have. Are there  
6 others?

7 RICHARDSON: Richardson, Marshall. On 8.10, on the  
8 shock test, we at Marshall don't normally shock test flight  
9 hardware that we're going to fly. Normally the shock test  
10 is only performed during your qualification test, where you  
11 want to qualify a basic design of a component, or a black box,  
12 or whatever it might be - - or a cell.

13 It seems to me this wouldn't be desirable, to run  
14 a 100 percent shock test on all your flight cells -- not unless  
15 there's an application where they're going to be repeatedly  
16 shocked.

17 I don't know -- maybe you have this in mind.

18 SCOTT: I think we skipped over paragraph 8.9. If  
19 you'll bear with me to keep this thing in order. I don't have  
20 any formal comment here on 8.9. Are there any others?

21 GASTON: Gaston, Grumman. There is apparently  
22 some alternate procedure to this charge for five minutes and  
23 let stand for 24 hours. The alternate procedure is to apply  
24 a one-ohm resistor for 16 hours, and let the cell stand for 24  
25 hours, and then measure the voltage build-up. We have found

1 this a very sensitive test, and possibly more sensitive than  
2 this test procedure.

3 I would like very much to see the alternate procedure  
4 included in here.

5 SULKES: Sulkes, U. S. Army Electronics Command.  
6 One thing that appears important -- these tests should defin-  
7 itely be specified by order. As Floyd just pointed out, this  
8 high-current discharge appears to be a very good test after  
9 your shock and vibration, if it does pick up things like weld  
10 failure.

11 The same thing with the charge retention, where you  
12 may induce a short. You might be able to pick that up after  
13 shock and vibration.

14 But the order of tests I believe is extremely impor-  
15 tant, and should definitely be specified.

16 GASTON: Gaston, Grumman. I have an additional  
17 comment on paragraph 8.9. I think the temperature should be  
18 specified.

19 GROSS: Gross, Boeing. On 8.9, I would think that  
20 the title of the -- the title "Charge Retention" is not  
21 perfectly correct. It's basically a short test. You're  
22 testing to determine if you have a short.

23 STROUP: Stroup, Goddard. On that 8.7, before we  
24 get too far away from that, I want to say one thing. The 5C  
25 rate discharge for detection of bad connections, while I would

1 it is a very good test, for certain cells, that would not  
2 hold true in my opinion as well as you would like for it to  
3 hold true for other cells. There are some cells that will,  
4 for instance, withstand a 30C rather than 5C rate, and still  
5 be better than one volt for a period of 10 seconds without  
6 any problem. Sonotone has made many of these, by the way,  
7 and I imagine they're still doing it. And of course other  
8 manufacturers are making cells that easily do 10 seconds at  
9 better than one volt at a rate of around 20C.

10 FORD: I would like to make a general comment in  
11 regard to paragraph 8.9, for information purposes. We are  
12 currently involved in-house in a program to look at both this  
13 type of test, charge retention test, and the other type of  
14 test we refer to as the open circuit voltage recovery test.  
15 And as Steve indicated, we found out that both tests are very  
16 sensitive to temperature. They are also somewhat sensitive as  
17 to how the cells are discharged. They are also sensitive to  
18 whether the cell has been cycled many times previous to  
19 running this test.

20 So my comment at this time is that we have two tests  
21 available to us. Both of them have certain limitations that  
22 I think we all should be aware of. And I'm not sure we know  
23 at this time what all these limitations are.

24 It was very surprising to us to find out that regard-  
25 less of which test you ran, there was a difference in open

1 circuit voltage recover that you got after cycling, as  
2 compared with after a recondition cycle on a fairly new cell.

3 GROSS: Gross, Boeing. We should recognize in  
4 paragraph 8.7, in a high-current discharge test, we should  
5 recognize that the small cells will have much greater capa-  
6 bilities for high voltage at high discharge rates. The large  
7 cells, especially the very large cells, will find this a very  
8 difficult test and probably not necessary.

9 So the high-current discharge rate should really be  
10 related to the size of the cell.

11 RAMPEL: Rampel, General Electric. 8.9, Charge  
12 Retention. I would like to suggest a compromise situation  
13 between the open circuit recovery and the C/10 for five  
14 minutes and drop to C/10 to C/20.

15 CORBETT: Corbett from Lockheed. The label on 8.9  
16 reminds me that I see nothing in here that's similar to a  
17 charge retention test -- that is a test of whether the cell  
18 holds its capacity for a period of days or weeks or so. And  
19 since there's been a lot of discussion in this particular spec  
20 concerning impurities, and since this has been related to the  
21 amount of capacity that a cell holds for a period of time, I  
22 think this might be a good performance test to include as a  
23 measure of whether the cell is good under those conditions.  
24 That is, some sort of a test for perhaps a period of days, to  
25 see what the -- how much capacity had remained in the cell, and

1 perhaps decide upon a fixed percentage of rated capacity which  
2 would have to remain in the cells for a period of stand at  
3 perhaps an elevated temperature.

4 FORD: Could I clarify your suggestion, that on  
5 a 100 percent basis --

6 SCOTT: I have a comment to that. It seems to me  
7 that that is getting pretty close to a highly applications-  
8 oriented type of test, because in my knowledge there aren't  
9 too many batteries, nickel-cadmium batteries, being used in  
10 such a way that they are required to retain much charge on  
11 open circuit. Maybe I just don't know about them, but if  
12 they are not, then it seems to me possibly somewhat academic  
13 as to what the long-term, open-circuit charge retention is.

14 CORBETT: I guess I would have two comments to that,  
15 Dr. Scott. One is that I think it's a good performance test  
16 which indicates the general health of the cell; whether or  
17 not there happens to be an application for it, this is impor-  
18 tant.

19 And another point is that this is related somewhat  
20 to the efficiency, and we have seen considerable variation  
21 from cell to cell of the charge efficiency, which I think is  
22 something that is undesirable from the systems standpoint for  
23 an orbiting spacecraft -- particularly low orbiting spacecraft.

24 The second point is that usually when you're sitting  
25 in a spacecraft on the pad, it may be for usually more than



1 two to three days, and I think it's an undesirable feature to  
2 have to continually trickle the battery, or at least you  
3 wouldn't want to have to depend on that.

4 Also, in synchronous orbit, it requires two to three  
5 days for a vehicle -- if I understand that problem correctly --  
6 for a vehicle to get into the orbit that it's meant to be in.  
7 And I think this is equivalent to the kind of stand time that  
8 you need to meet for the application.

9 SCOTT: Other comments?

10 (No response.)

11 So now we're back to 8.10, Shock Test. Steve?

12 GASTON: Gaston, Grumman. I agree with the earlier  
13 comment from the gentleman from Marshall. I believe if I will  
14 run shock tests on cells at an earlier point, I might find  
15 them later on rejected by the systems people, having over-  
16 tested my units. So I'll be somewhat cautious about adding  
17 shock tests at this moment. Because as far as I know, most  
18 flight units are not exposed to shock tests, pre-qualification  
19 tests.

20 SCOTT: Excuse me -- may I interject some of the  
21 written comment here, which I failed to do earlier?

22 Comment:

23 "We are uncertain as to the need of an 80<sub>g</sub> peak  
24 during shock test. Perhaps we can be enlightened as to  
25 the technical need."

1 And then on 8.10 and 8.11 combined:

2 "If these shock and vibration tests are general  
3 enough to cover most operating environments, then  
4 these sections are acceptable.

5 "Also, this type of testing, if performed on a  
6 100 percent of the lot, would directly impact on costs,  
7 since it requires more direct labor and would also  
8 lengthen delivery time."

9 And then further, on 8.11:

10 "In general, we find the vibration levels rather  
11 high and more in line with qualification type levels  
12 rather than cell acceptance. Is there some particular  
13 reason for extending these levels?"

14 If there is no comment we'd better proceed here.

15 I have no comments here on 8.12. Are there any  
16 others?

17 FORD: I have a comment. I feel like that following  
18 the cell being subjected to a leak test of this type, it  
19 should be followed by a chemical leak test.

20 SCOTT: I have some comments on 8.13. Comment:

21 "We generally use X-ray techniques to determine  
22 the proper location of internal components, and for  
23 showing the absence of foreign materials. It would  
24 require 7 or 8 views on each cell to determine weld  
25 integrity and at that would be extremely difficult on

1 a completed cell.

2 "We suggest that the question of X-rays be something  
3 which is negotiated between the manufacturer and his  
4 customer."

5 Further comment? This section must also include  
6 the minimum acceptable resolution as specified by a minimum  
7 detectable particle size. Measurement can be effected by  
8 using a penetrometer. Particles 0.10 inches in the smallest  
9 dimension can readily be detected.

10 Any comment from the floor? Steve?

11 GASTON: Gaston, Grumman. I agree with the earlier  
12 comment which says the weld joint -- to detect the weld joint  
13 integrity, or the weld joint failure by means of X-ray -- or  
14 weld joint defects by means of X-ray, is not a practical  
15 method. I don't think it can be conducted on a large scale.  
16 We tried it and we were not too successful.

17 However, you can detect impurities, particle sizes.  
18 And we have a 10 mil size arbitrarily as the rejection  
19 criterion. Any particle which can be seen outside the spec  
20 integrity, around the edges or the tub, inside the cell, this  
21 is subject to rejection -- any particles larger than 10 mils.

22 RICHARDSON: Richardson, Marshall. You say you  
23 defined particles in there you can -- where are you seeing  
24 these -- up above the plate area?

GASTON: Above the plate area, and you see it on the

1 edges or the sides.

2 RICHARDSON: We've had some experience at Marshall  
3 X-raying silver cells. We ran into a little problem where we  
4 were getting short, and so on, and we, in looking into some  
5 of these cells, on the edges of the plates going in on an  
6 angle X-ray, you can actually see bent corners of the plates.

7 So we started X-raying all cells on one of our stage  
8 programs, on the corners. I believe that was the only two  
9 places we were looking at. We didn't go on a full X-ray of  
10 the cell, like, say, look for particles that were loose up  
11 there.

12 So we wind up rejecting cells if we see something  
13 in the X-ray there that might look like it's bad, we just  
14 automatically reject the cell. It may or may not be the cause  
15 of a possible shorting, you know.

16 GASTON: Yes, we are considering the whole X-ray as  
17 established. At the moment we are not able to determine  
18 whether this is a metal particle or any other particle. That's  
19 one of the difficulties. Now if it's a non metallic particle,  
20 apparently it's not subject to shorting. But the metal  
21 particle would be. So we will have to reconsider that, the  
22 whole X-ray analysis.

23 RICHARDSON: Now in only one case -- we have one  
24 type of cell that's got a narrow plate, and it was shorted at  
25 the Cape. And in the failure analysis we went ahead and, since

1 we knew the general area in the cell, because the case was  
2 warm, we X-rayed there, we could actually see the particle  
3 embedded in between the plates. It was a silver particle.

4 But here again, if you had to do this on a production  
5 basis you'd have to take about 8 or 10 shots so that you  
6 could look perpendicularly, right parallel to the plates.  
7 Because you'd be unable to take one shot and look through all  
8 the plates. It would be quite an expensive process to do it  
9 as an acceptance test, to take 10 X-ray shots of every cell.

10 And then here again, you may or may not see it.

11 GASTON: Yes, I agree it's not a perfect method in  
12 production. At the moment we're only taking three pictures.  
13 We take two views prior to sealing and one view after sealing.  
14 And we have detected some particles. We haven't quite estab-  
15 lished what they are, whether metal or not. But we have seen  
16 particles larger than 10 mils, and we have not used those  
17 cells.

18 May I ask you, in the silver-zinc cells, was that  
19 plastic case or metal case?

20 RICHARDSON: Plastic.

21 GASTON: Oh. With a metal case it's even more  
22 difficult.

23 RICHARDSON: Yes, I can imagine it would be horrible  
24 going through metal, and especially if you're trying to  
25 evaluate let's say the weld on the tab, if you've got cracks

1 or anything. Most of our X-rays are of weld joints, you know,  
2 on the stages, and here you're putting the film maybe right  
3 behind the weld joint, and you get a pretty good shot at it.  
4 And we even take angle shots. We're looking for porosity,  
5 internally in the weld joints, and the cracks, and porosity  
6 with sharp tails and various things of this nature. And that  
7 would be real tough, trying to find this internally in the  
8 cell at your tab area, I would think, to look for a bad weld.

9 GASTON: Well, I agree it's not a perfect method.  
10 But even an imperfect method is better than none. So I'd  
11 like you to look at it a little bit closer and see what we  
12 can come up with in this X-ray technique.

13 RICHARDSON: Then you have a question of evaluation.  
14 If you see something there, you should have standards for  
15 accept or reject; and here you get into all kinds of problems  
16 of what people see. And people have different machines they  
17 use that sometimes vary. And being able to resolve certain  
18 items in the X-ray. And some films they'd be less dense than  
19 others. And you'd get into quite a problem with X-ray inter-  
20 pretation in this area.

21 So you have to be awfully careful, I think, when you  
22 determine accept or reject criteria when you're looking at  
23 X-rays - unless it's something obvious -- you've got a blob  
24 in there that you can obviously see.

SCOTT: May I comment? How long are you guys going

1 to carry on here?

2 GASTON: Just one more comment. In case of doubt  
3 I'd much rather reject one more than one too little for flight  
4 batteries. We might take a perfectly good cell and reject  
5 it because there would be a shadow in there.

6 But it is an additional tool that I like to use and  
7 I'd like you to explore it a little bit more.

8 SCOTT: X-raying of cells, nickel-cadmium cells in  
9 steel containers, is not something that is new. TRW has been  
10 doing this for years and years. We've gone through all the  
11 agonies that you have just recited. Indeed, they are many.

12 The net outcome is that we still firmly believe that  
13 the advantages outweigh the disadvantages. I could recite  
14 the whole story for anybody, if they have time. We have  
15 worked out as quantitative a standards, methods of evaluation  
16 and so forth as the state of the art permits. All this has  
17 been implemented, is being used, and so it isn't something  
18 that we're just tossing in here. I think it's something that  
19 has demonstrated definite usefulness from the point of view  
20 of the user.

21 A more detailed comment: We routinely obtain a  
22 pretty good view right between the plates of a nickel-cadmium  
23 cell, and can pretty well see through almost all the plates  
24 on one, single shot -- right down through the separator. It's  
25 not perfect, but you don't need 3 or 4, 5 or 8 views at all.

1 If you back off far enough, use the proper conditions, you  
2 can split the plates -- even through the steel container.  
3 It's just a matter of deciding you're going to do it, and it's  
4 worthwhile.

5 So, there's a chunk of technology here, I think,  
6 that's worthwhile looking at.

7 NIETZEL: Nietzel, T.I. I'd like to concur with  
8 Mr. Gaston, that particles as small as 10/1,000ths can be  
9 readily detected by X-rays.

10 SCOTT: 8.14. I guess I have combined comment on  
11 8.14 and 8.15:

12 "These steps are readily performed, but they will  
13 also impact on cost and delivery time of a given lot."

14 That's all the formal comments I see here. Any  
15 others?

16 (No response.)

17 I guess that wears that out.

18 GASTON: May I make just one more comment please?  
19 On paragraph 8.3, on the electrolyte leakage test. I'd like  
20 to suggest after washing the plate with a water, I think it's  
21 specified, to have a vacuum bake added to remove any water  
22 which is outside the cell and which are on terminal areas.  
23 Some terminal designs have a cavity which is open to the  
24 exterior and which is covered with plastic. There is a  
25 possibility that a water trace could penetrate through this



1 and cause possible corrosion.

2 We have added as a safety feature, we have added a  
3 vacuum bake.

4 STROUP: Stroup of Goddard. Did anyone make a  
5 correction on the leak rate on 8.12, from 10.6, the helium  
6 leak rate -- shouldn't that be 10 to the eighth?

7 HALPERT: You're talking about changing  $10^{-6}$  to  
8  $10^{-8}$  there?

9 STROUP: Yes. I wasn't coming up with anything  
10 new there. This correction has been made at other points  
11 throughout the document. And certainly, if you're going to  
12 be consistent, then you would have to continue with that one.

13 HALPERT: Okay.

14 STROUP: I would like to say one other thing on  
15 that. I would like to make the observation that if you have  
16 two cells, one cell that does not leak that has helium in it,  
17 and one cell that does leak and is supposed to have helium  
18 in it, that you'll get the same result on tests, with this  
19 particular test. That is, both of them will show good fields.

20 HALPERT: If there are no more comments, I'd like  
21 to move that we take a break here. And I will mention that  
22 there is coffee in the back as there was yesterday. We also  
23 have copies of the specifications for zinc plates and for  
24 silver plates down here; if you haven't picked up a copy and  
25 you'd like to scan them over before tomorrow's meeting, they're

1 available.

2 I would like to resume -- keep the time to fifteen  
3 minutes at the very most, so we can finish up as early as we  
4 can this afternoon.

5 So let's come back rather quickly, please.

6 (Recess.)

7 HALPERT: Gentlemen, please take your seats. We  
8 have something to cover and we would like to cover it before  
9 it gets too late.

10 There was a comment about number 8 that Floyd Ford  
11 wanted to make before we completely close out that section.

12 FORD: Yes. The comment is in reference to 8.9,  
13 Charge Retention test, or whichever one results.

14 This type of test is somewhat sensitive to the  
15 pressure applied to the broad face of the cells. In other  
16 words, the cell should be constrained in a configuration under  
17 pressures that are somewhat similar to the conditions that it  
18 will be subjected to in a spacecraft battery, when this type  
19 of test is run.

20 HALPERT: Okay. If there's no comment about that,  
21 that will complete section 8 and we'll go on to section 9.

22 Section 9, just by way of introduction, is -- we  
23 call it a sampling for production cells, and taking those cells  
24 apart and doing an analysis of the materials in the cells.

25 This sounds like a duplication of some of the

1 earlier work and some that may not be required -- that should  
2 not be required since you've already constructed these cells  
3 based on given specs.

4 But I think it's a matter of assuring, at the  
5 beginning, anyway, of assuring -- giving us confidence that  
6 what we are really producing -- we are going into these cells  
7 and are looking like they're supposed to after they have been  
8 assembled into a final product.

9 I'm sure that's one of the first things -- that after  
10 the spec has been utilized to some extent and we have a lot  
11 more data, I think this is one of the first things that will  
12 be reduced considerably.

13 But I would like to read a couple of comments I do  
14 have in general. I don't have any specific comments about  
15 any of the items in there -- just two general comments on the  
16 entire area.

17 "Regardless of which of the specified tests are  
18 performed, there are no dimensions or tolerance levels  
19 specified. In general, a large amount of data will be  
20 generated without any immediate use of a parent plan  
21 to use this information.

22 "Also, the need in general of these tests is  
23 questionable. If the previous testing of plates, electro-  
24 lyte and separator has been performed, these tests  
25 become redundant and costly -- up to five percent

1 increase in the finished cell price. There are no  
2 specific comments other than those previously made  
3 regarding method and types of analyses."

4 Second comment:

5 "The sampling procedure of using a minimum of five  
6 cells could be extremely expensive on a small production  
7 run. Although we consider this an excellent experimental  
8 program to determine potential changes due to electrical  
9 use of the cells, we are not sure that this is justified  
10 in procurement type of contracts, and it may be better  
11 done in a controlled experiment."

12 Those are the two comments I have on Section 9.  
13 Does anybody care to make a comment about the necessity --  
14 the use of this type of test in a specification?

15 HENNIGAN: I would like to make one comment here,  
16 I think, in the separator area. I think that this is one  
17 area that should be looked at after the cell has been used.

18 HALPERT: Any other comments regarding number 9 at  
19 all? I will not cover the individual sections. We have two  
20 pages in which much of the analyses is done similarly to what  
21 has been done before on the basic materials.

22 Again, the intent here is to assure that we have  
23 the materials in the cells that we intended to put in there,  
24 and to make sure that nothing has changed in their manufactur-  
25 ing process. No question or comments concerning number 9?

1 REED: Reed, from Battelle. I have a question about  
2 the intent of paragraph 9.2.7. It says, "Using the plaque  
3 from Paragraph 9.2.5, determine the strength of sinter. . ."  
4 and so forth. 9.2.5, this is the one in which you've just  
5 performed a metallurgical reduction on positive plates.

6 Do you want this strength of sinter and surface area  
7 determined on the reduced plate, or on something else? It's  
8 not clear to me what you have in mind.

9 HALPERT: In 9.2.7 when we're talking about the  
10 plaque that's left after the extraction -- and in 9.2.5, we're  
11 talking about the plate before we do the extraction. This  
12 tells us something about the corrosion.

13 GROSS: Gross, Boeing. In 9.2.7 it will be found  
14 that the plaque has corroded in a very non-uniform way, and  
15 this will present problems. Some areas will be very much  
16 changed and other areas will be changed to a lesser extent.

17 NIETZEL: Nietzel, T.I. Jerry, I believe what you  
18 mean here is that the plaque from 9.2.6 -- that is what you  
19 would use. You take 9.2.6, which is the plate, extract from  
20 that your active material, and then take the resultant plaque  
21 and go back and look at your sinter strength, surface area,  
22 pore volume, pore size distribution -- and then you would try  
23 to compare that with the initial plaque used prior to impreg-  
24 nation.

HALPERT: That's right. It's 9.2.6. That's correct.

1 NIETZEL: Then that should be 9.2.6.

2 HALPERT: Right.

3 NAGLE: An additional step that you might use here  
4 that would give you information in section 9, would be to  
5 determine where your cell balance is before you take the  
6 thing all apart; find out where your cadmium is, what kind  
7 of a ratio you have between positive and negative.

8 HALPERT: I think that may be discussed a little  
9 bit further, in 10.

10 Are there any other comments concerning section  
11 number 9?

12 (No response.)

13 Okay. Then we'll go on to section number 10, the  
14 sampling of production cells - electrode capacity test. And  
15 I think Dr. Scott is going to stand in here.

16 SCOTT: Section 10 describes a tentative method for  
17 determination of the electrochemical capacity of the positive  
18 and negative electrodes in a completed cell.

19 Comment 1:

20 "We question the minimum value of the negative to  
21 positive capacity ratio of 1.5."

22 This is regarding, I guess, paragraph 10.0.

23 "We would again like to see the technical justifi-  
24 cation for this value and wonder if control experiments  
25 could bear this out."

1 Again, comments on 10.0:

2 "For those plate manufacturing processes which do  
3 not normally provide these data, this testing procedure  
4 is desirable, but will increase the price. Its major  
5 benefit is the measurement of the distribution of  
6 negative capacity. The range and distribution of positive  
7 capacity will be determined on a cell basis also in some  
8 formation procedures."

9 Another one specifically regarding 10.0:

10 "A negative to positive ratio of 1.5, based on  
11 flooded formation testing is considered an arbitrary  
12 value, since the need for excess negative capacity and  
13 its distribution is effected by the following:

- 14 (a) Charge rate
- 15 (b) Discharge rate
- 16 (c) Temperature
- 17 (d) Overcharge rate
- 18 (e) Degree of overcharge
- 19 (f) Life
- 20 (g) Plate loading and thickness.

21 The amount of and distribution of negative capacity  
22 is considered a design parameter which is selected based  
23 on the duty cycle."

24 End of formal comments on 10.0. I would like to say  
25 that I don't believe that during the formal discussion of

1 comments on this section that we should get into a big hassle  
2 on the exact criteria. I think we will probably come back to  
3 this when we finish the more routine discussion of these  
4 things, and I feel that this is indeed a difficult question,  
5 of what this ratio should be, and why; and getting into that  
6 discussion now would unduly prolong the finishing of the  
7 normal business at hand.

8 So I would suggest we wait until we finish, and then  
9 come back to this point later.

10 Other than the actual numbers that we are aiming  
11 for, are there other kinds of comments on 10.0?

12 (No response.)

13 10.1, Sampling Rate. I have no formal comment on  
14 that. Are there any other?

15 CARR: Carr, Eagle-Picher. Excuse me, Dr. Scott.  
16 I have just one comment regarding the sampling rate. It seems,  
17 since this is considered a destructive test, and we're talking  
18 about a 10 percent sample, or some other sampling basis --  
19 but these are pretty high numbers and do increase the cost  
20 quite a bit.

21 SCOTT: Yes, I believe that possibly some maybe  
22 more statistically digestible sampling plan could be approp-  
23 riate here. It certainly -- I think that the actual percentage  
24 should be a function of the test lot size and other process  
considerations. So this is a rather arbitrary number right



1 now, subject to negotiation.

2           RAMPEL: Rampel, General Electric. The electrode  
3 capacity test in 10.0 is very dependent upon the sequence of  
4 testing before it -- the history -- particularly in regard to  
5 what you're going to find in the way of electrochemically  
6 active cadmium.

7           So it's important to spell out conditions beforehand,  
8 the history.

9           SCOTT: I believe that is done to some degree in  
10 10.2. Are you saying that that's not sufficient?

11           RAMPEL: No. I see you have it covered.

12           SULKES: Sulkes, Army Electronics Command. One  
13 question -- is this test on a completely random basis, or sort  
14 of use the ones that are just not that desirable?

15           (Laughter.)

16           SCOTT: I guess I don't understand the question.

17           SULKES: Well, in other words, it doesn't call out  
18 a completely random basis, and if I was the manufacturer and  
19 I had to make a subjective judgment, I would give the ones  
20 for this test that are, let's say, slightly out of voltage or  
21 slightly out of spec -- or within spec but out of tolerances  
22 on capacity -- in other words, that type of thing. You would  
23 try to save your best ones for your actual flight batteries.

24           SCOTT: Any comments? It seems to me that if  
25 statistical sampling is done honestly, it cannot put up with

1 any shading of that kind, and you'd pick, presumably, as many  
2 good ones as bad ones.

3 On 10.2, I have some comments:

4 "To assure uniformity for lot to lot testing, the  
5 value of  $5/C$  ohms should be based on  $C$  equal to average  
6 delivered capacity of the lot of cells."

7 Any further comment on that?

8 FORD: Ford, NASA Goddard. If I interpret that  
9 correctly, it means every cell, or every lot of cells, may  
10 be run at a different current rate, and consequently a  
11 different current density?

12 SCOTT: That would be the way I would interpret it.

13 GROSS: Gross, Boeing. Relative to the last comment,  
14 I would personally prefer to see the rated capacity closer to  
15 the delivered capacity, and continue to use rated capacity  
16 for a great many of the tests that we do.

17 But there is a problem if the rated capacity has too  
18 great a range.

19 SCOTT: Paragraph 10.3. Comment.

20 "The cell should be discharged without the addition  
21 of electrolyte, since this increases the efficiency of  
22 the electrode and will yield higher usable cadmium metal  
23 levels than would be usable in the starved condition.

24 On charge the cell can be operated under a partial  
25 vacuum to remove the evolved hydrogen and oxygen."

1 That's all of the submitted comments I have. Are  
2 there others?

3 (No response.)

4 I might just mention one correction, or maybe a  
5 couple, which may or may not be obvious. In Section 10.4,  
6 the expression for  $(T)_P$  should read "Time from start of  
7 discharge." 3

8 And down here in the third from the last line, the  
9 expression for excess capacity of total negative over positive,  
10 there should be brackets around the difference between  $(T)_N$   
11 and  $(T)_P$ . 3  
12 3

13 And in the last line, there should be brackets around  
14 all three terms following I .  
15 0

16 SULKES: Sulkes, Electronics Command. I started  
17 looking at these equations, and maybe somebody else has found  
18 it too who can explain it to me -- but it would appear that  
19 last relationship should be  $(T)_N - (T)_N$ , and there should be  
20 3 1  
21 no need for positive capacity at all, in there.

22 SCOTT: Well, because this is a calculation of  
23 excess, it's excess relative to positive. So positive has to  
24 be deducted.

25 SULKES: Well, first, shouldn't it -- wait a minute --

7 SCOTT: I can see there's a typographical error  
8 here. One of those two has to be (T ) in the last line.  
9 N  
3  
Obviously, they can't be both the same. I missed that.

12 BOGNER: Shouldn't it be (T) - (T) - (T) --  
N N P  
3 1 3

Does that help?

22 BOGNER: Bogner, JPL. Maybe changing the terminology  
23 of the terms -- it might be nit picking, but it might be more  
24 understandable -- if you called the first term -- just call it  
25 (T) , total negative capacity; next term, call that excess

1 negative capacity; and the third term, on charge negative  
2 capacity, or excess active cadmium hydroxide. These might be  
3 more logical, easily understood terms.

4 SULKES: One other correction. In step 3, I believe  
5 the first minus one volt should be plus or minus -- the plus  
6 or minus sign should be reversed on the one volt terms.

7 SCOTT: I guess I missed that. What --

8 SULKES: Step 3, your voltages should start off plus  
9 one volt, plus 1.5 and so on. The last term should be minus  
10 1.0. It's probably just a typo -- transposing the pluses and  
11 minuses on the one volt.

12 SCOTT: Yes, that's correct. The first one should  
13 be plus one, the last should be minus 1.

14 Do you have something you would like to open the  
15 discussion with now, on this section? Or do you want to --  
16 what would you like to do?

17 HALPERT: Let's finish up the section, and then  
18 we'll go on and --

19 MC CALLUM: I had a question on paragraph 10.2, where  
20 it talks about 5/C ohms; I don't recognize that unit.

21 SCOTT: That's a new unit; I invented it.

22 (Laughter.)

23 I don't believe that one ohm is appropriate for all  
24 size cells. I think it's going to give you a different  
25 result with every different capacity. So I think you need to

1 relate that load to the capacity of the cell. And that's my  
2 approach -- I'm just suggesting that.

3 MC CALLUM: As a dimension of reciprocal hours --

4 SCOTT: Well, you know how this term C is used.  
5 Everybody uses it in different ways. This is just -- I'm  
6 not trying to make the units consistent here. I've never been  
7 able to figure out how to -- what a C/2 rate means, in terms  
8 of units. So, it's just a number -- it's a resistance which  
9 is numerically equal to 5 ampere-hours over the rated capacity  
10 in ampere-hours.

11 FLEISCHER: Well, what you have is 5 ohms per ampere  
12 hours. If you have a one ampere-hour cell, you have 5 ohms  
13 per ampere-hour. It's ohms per ampere hour.

14 MC CALLUM: That isn't what he means.

15 FLEISCHER: Yes it does. That's what he means.

16 MAURER: It amounts to that.

17 FLEISCHER: You mean if you have 100 ampere-hours  
18 cell you take 5/100 for your resistance? Don't you?

19 SCOTT: That's right. I think when you're talking  
20 about a small range of capacities of cells, like 6 to 12, or  
21 something like that, it may not make a difference. But when  
22 you're working with a range of 6 to 100 I think it makes a  
23 great deal of difference.

24 HALPER: May I get a a clarification of that? This  
25 means that if you had a one ampere-hour cell, you'd be using

1 five ohms for a one ampere-hour cell, is that right?

2 SCOTT: Well, that would be the logical --

3 HALPERT: Okay, and if you're using a 100 ampere-  
4 hour cell you'd be using 5/100?

5 SCOTT: That's right.

6 HALPERT: Smaller resistance.

7 SCOTT: That's right.

8 HALPERT: I'm sorry. It's in the right direction.

9 (Laughter.)

10 SCOTT: Well, doggone you --

11 (Laughter.)

12 SCOTT: Do you want to open the discussion to the  
13 business of what the negative to positive ratio should be?

14 HALPERT: I want to finish number ten.

15 SCOTT: Okay.

16 GROSS: Gross, Boeing. I just want to point out the  
17 typo error in Step 2. On the "greater than" signs, you want  
18 cell voltage greater than 1.53 here I'm sure, and you want to  
19 get more than -- greater than 50 percent hydrogen.

20 HALPERT: Which paragraph is this?

21 GROSS: 10.3, at the top of the page -- step 2.

22 HALPERT: I'm sorry, you'll have to repeat where  
23 you are.

24 GROSS: Paragraph 10.3. Step 2.

25 SCOTT: That's correct.

1 GROSS: Second sentence -- "Cell voltage should be  
2 greater than 1.53 volts."

3 HALPERT: Okay.

4 GROSS: And "gas evolved should contain greater than  
5 50 percent hydrogen."

6 HALPERT: That's less than 50 percent.

7 GROSS: Yes -- I presume that you want it the way I  
8 just read it.

9 SCOTT: It should be "greater than." That's correct.

10 HALPERT: It should be "greater than."

11 GASTON: Gaston, Grumman. Just one suggestion.

12 Since I think we all know what C means, but maybe for clarifi-  
13 cation it should be defined in definitions of what C means --  
14 just for clarification.

15 HALPERT: Are there any other comments regarding  
16 section number 10?

17 FORD: Are we coming back?

18 HALPERT: Well, we'll finish number 11 and then  
19 we'll get into some more open ended stuff that we haven't --

20 FORD: Okay.

21 HALPERT: -- finished yet. Okay, for number 11, our  
22 illustrious chairman, Mr. Billerbeck will handle.

23 BILLERBECK: Well, we should be able to finish this  
24 one very quickly, since we have no written comments on this  
25 section. And I think it's a very simple thing, and the



1 intention of the section is just to ensure that the cells  
2 are prepared and packed for shipment in a manner so they don't  
3 get damaged.

4 Perhaps the simplest thing to do is just ask if  
5 there are any comments from the floor on the first page,  
6 11.0 through 11.6.

7 CARR: Carr, of Eagle-Picher. With reference to  
8 11.2, is there any real reason to ship a cell in a short-  
9 circuited condition?

10 BILLERBECK: I'll try to answer that. I think that  
11 there is a possibility of short-circuiting during mechanical  
12 inspection, which would be avoided if the cell is in a shorted  
13 condition when shipped.

14 GASTON: Gaston, Grumman. A suggestion on paragraph  
15 11.2. This "discharged" here implies there's a possibility  
16 the cells might be charged and have to be discharged. Maybe  
17 the discharge regime should be referred to in some earlier  
18 paragraph. And maybe -- "short-circuited condition" -- maybe  
19 the means of how a cell should be short-circuited should be  
20 specified, like a copper wire wrapped around it.

21 And another suggestion on paragraph 11.3, the unit  
22 packaging. Maybe the cell should be placed in a heat-sealed  
23 polyethylene bag prior to putting into the container. And  
24 maybe each container should be marked on the outside at least  
25 with a serial number.

1 Another general suggestion is that all cells should  
2 be stored at as cold a temperature as possible -- I should  
3 say as cold a temperature as possible -- cool temperature.  
4 For long-term storage.

5 BILLERBECK: Any other comments on 11.0 through  
6 11.6?

7 GROSS: Gross, Boeing. On 11.2, I would appreciate  
8 hearing from people who might know, whether there is a differ-  
9 ence between being shipped or stored for a long time, short-  
10 circuited, or versus stored fully discharged, but open-circuit-  
11 ed.

12 I recall having heard that there is a difference,  
13 but I have no facts. And if there are some facts, I would  
14 certainly like to hear about them.

15 BILLERBECK: Any comment on that?

16 HENNIGAN: One of the reasons is to keep that  
17 voltage off the seal so we don't have any corrosion in storage.  
18 It was very helpful, I think, when we had one seal on there.  
19 But this is done as a matter of practice now.

20 FORD: Ford, NASA Goddard. Right on here I don't  
21 see any indication of a high temperature limit. In shipping,  
22 these cells could be put in a cargo hold such as the tempera-  
23 ture would exceed -- could be extremely high. There may even  
24 be a possibility of separator damage if the temperature got  
25 too hot. I think this should be mentioned.

1 BILLERBECK: Any other comments?

2 SULKES: Sulkes, U. S. Army Electronics Command.

3 In regard to Floyd's comment on temperature, there are these  
4 temperature labels which can be bought for a very few cents,  
5 and can be applied to these individual cells, and will give  
6 you an indication of how high the thing has gone. In other  
7 words, you can set a limit of 160 or 180, and it will indicate  
8 if it has gotten that high.

9 BILLERBECK: I think that we can move on to the  
10 next page, and - - 11.7, through the end of this section.  
11 Any other comments on that, from the floor?

12 (No response.)

13 All right. Fine. I think I'll turn the meeting  
14 back over to Jack Halpert then.

15 HALPERT: Okay. I think we're covered the specifica-  
16 tion as well as we can, by number, at this particular moment.  
17 And before I get into some general points, I did want to make  
18 this announcement again. We will be meeting here in this  
19 room tomorrow morning at nine o'clock, and I'd like to get  
20 started on time at nine tomorrow.

21 We only plan to go until one o'clock, in terms of  
22 talking about the silver spec, the zinc spec, and the silver-  
23 cadmium spec.

24 So those of you who want to make your reservations  
25 and check out of your motels can plan to be out by one o'clock.

1           Second of all, if you haven't picked up the specs  
2 and you want to take them back with you this evening, there  
3 are still copies sitting here, and I do also want to make  
4 note that if you have not put your proper address on that  
5 sign-in sheet, there's still the chance to make the proper  
6 changes down here so that you do receive a copy of the minutes  
7 of this meeting when they are completed.

8           Okay, at this point, I'd like to open for some  
9 general discussion, and I would like to do it in the following  
10 manner. I have received permission from there of the manu-  
11 facturers to read some general comments of theirs with regard  
12 to this specification, and their feelings for it. I thought  
13 you users and the Government people, might like to know how  
14 they do feel about it, and this may be a chance for you to  
15 hear how they feel and maybe ask them some questions about  
16 these feelings. Number one:

17           "Gulton Industries is deeply appreciative of the  
18 importance of nickel-cadmium batteries for the space  
19 program. We are more than sympathetic with the objec-  
20 tives of the above specification document and welcome  
21 the interest and concern of the parties involved in  
22 this preparation. We have always attempted to impose  
23 the maximum practical amount of control and selection  
24 of materials, processes and testing, to obtain maximum  
25 reliability and performance, compatible with reasonable

1 costs and acceptable time periods.

2 "We believe, however, that this document as present-  
3 ly written, imposes standards and levels of control on  
4 testing which are probably beyond those required to  
5 assure maximum reliability and performance, and are  
6 impractically expensive and time-consuming.

7 "It is our recommendation that specific programs  
8 be initiated to explore many of these areas and the  
9 results used to implement or modify the present docu-  
10 ment. We have made specific recommendations in this  
11 regard to NASA Goddard, Electrochemical Power Section,  
12 and others, with the cooperation of certain of the  
13 prime contractors, and NASA has achieved some results  
14 which are considered in a specific comment which we  
15 will offer.

16 "Nevertheless, if mandatory, we can and will meet  
17 the specification as written, given sufficient time,  
18 money and equipment. However, consistent with the  
19 invitation to which we are responding, we intend to  
20 comment specifically as listed in the attached outline."

21 And some of the comments given today are -- and  
22 yesterday -- are relative to that.

23 As to the General Electric comments:

24 "Both the General Electrical technical personnel and  
25 the cognizant management people have read and studied the

1 subject specification very carefully. Each subscribes  
2 to what we believe to be the intent of the specification,  
3 the assurance of aerospace cell reliability.

4 "General Electric's battery business section recog-  
5 nizes the desirability of specifications which incurs  
6 the production of spacecraft type nickel-cadmium cells  
7 in a well-controlled, reproducible manufacturing process.  
8 We see this as the goal of the interim specification.

9 "However, we are concerned about the means proposed  
10 in the specification to ensure repeatability. First,  
11 we are concerned about the numerous tests to be made  
12 with no limits. We interpret this to mean that a later  
13 date the same test is to be made on another lot of cells  
14 and the results are expected to fall within the same  
15 general area. This method of specification has the  
16 drawback of exposing a vendor's complete processes and  
17 process controls to the public.

18 "We believe this type of data, relative to our  
19 manufacturing process, to be proprietary information and  
20 will be forced to take exception to such a requirement.

21 "Using this particular specification would increase  
22 the procurement lead time for cells and add materially  
23 to the cost. The General Electric's battery business  
24 section has procedure in place aimed at achieving high  
25 reliability and repeatability. It is a well-documented

1 and controlled process, incorporating a system which we  
2 call an indentured parts and process list.

3 "This list is tied to a specific catalog number unit  
4 which in turn is tied to a specific customer specifica-  
5 tion and/or requirement. Each step in our process either  
6 has been written up or is being written up and the controls  
7 and method of testing, to assure proper processing are  
8 in writing. The contents of these documents are deemed  
9 proprietary; hence they are not sent out of the plant.  
10 However, they are available for the customer's examination  
11 at this location.

12 "The indentured parts and process list can be  
13 supplied to the customer on request. This list covers  
14 all the process documents, the number of the document,  
15 the number of the process control document, along with  
16 the date of issue and the particular revision number  
17 pertinent to this cell.

18 "With this system of documentation, in fact, we  
19 believe we are well on our way to meeting NASA require-  
20 ments. Although we are well on the way there, there is  
21 much work yet to be done. We would like to meet with  
22 NASA Goddard and discuss a program aimed at refining the  
23 documentation, making the system adaptable to any vendor's  
24 process without creating a need to divulge proprietary  
25 information."

1           The third comment I have is from the SAFT Company,  
2 who is tied of course, as you probably know, to both Gulton  
3 and the G.E. process. General comments:

4           "In addition to comments concerning specific para-  
5 graphs of this specification, we would like to offer the  
6 following general observations.

7           "SAFT believes the specification to be a significant  
8 achievement in the development of detailed processes  
9 and control requirements for the manufacture of nickel-  
10 cadmium cells for space applications.

11           "However, we question whether all the measurements,  
12 tests and controls which are included are required during  
13 the production of quantities of cells. It appears to  
14 us that all of the imposed requirements do not have the  
15 same importance with respect to the quality of the final  
16 product.

17           "Therefore, we suggest that this specification in  
18 its totality be initially utilized to qualify a process  
19 and its resulting products, to determine critical controls  
20 and measurements and define acceptable limits.

21           "Then, a second specification could be written  
22 applicable to the production quantities, which incorpor-  
23 ates only those controls found to be critical to achieve  
24 the required performance and reliability. It would be  
25 unnecessary, for example, to determine the spectrum of



1 porosity on as many samples of the spiral if it were  
2 found that this parameter varies very little, or has a  
3 small effect on the cell's characteristics.

4 "The above recommendation is primarily based upon  
5 our estimate of the cost to manufacture cells, utilizing  
6 all of the controls outlined in this specification. The  
7 installation of the equipment and procedures for pro-  
8 duction quantities would require a considerable invest-  
9 ment, difficult to calculate at this time, which would  
10 have to be amortized in the price of the cells.

11 "We estimate that to conform to all the requirements  
12 of this specification in production would increase the  
13 price of the cells 6 to 10 times the present price for  
14 space cells.

15 "2. It is our opinion that it is impossible to  
16 meet the specification without permitting the sorting  
17 of materials and components at various points within  
18 the manufacturing cycle. For example, the basic materials  
19 such as the substrate bands, nickel, cellulose binder,  
20 and separator, have characteristics which vary according  
21 to lots.

22 "In addition, the sintering and impregnation  
23 processes have not been entirely mastered, and the  
24 characteristics of these products are dispersed. With  
25 present technology it is possible to obtain satisfactory

1 average values, but not possible to reduce dispersions.  
2 An improved process control would definitely improve the  
3 products, but again would not diminish the dispersions  
4 within the limits outlined in this specification.

5 "Therefore, we recommend that at various steps of  
6 the manufacture, prior to taking samples for test and  
7 analyses, the components be sorted. This sorting would  
8 thus produce the 'lot' which would continue through the  
9 manufacturing cycle. The samples taken from the lot  
10 would then be tested to ensure that the sorting was done  
11 correctly. This point is discussed further in our  
12 comments on paragraph 2.4.2.

13 "3. Based upon the above remarks, we believe that  
14 the manufacture of high-reliability nickel-cadmium cells  
15 could be developed and realized in the following manner:

16 "Complete analysis of the manufacture of one lot,  
17 utilizing the controls and measurements provided in the  
18 specification.

19 "Determination of the critical points of the manu-  
20 facture and the characteristics of the components which  
21 have a bearing on final cell performance and reliability.

22 "Definition of the controls and measurement limits  
23 necessary in the production processes and components by  
24 classifying the defects in categories of different  
25 importance in order to arrive at the criteria for

1 rejection.

2 "Application via production specification of these  
3 controls to the production and test of component parts,  
4 allowing for sorting at various points in the process.

5 'Assembly of the cells, utilizing a controlled  
6 process.

7 "Control of testing of cell lots, using a sampling  
8 procedure without any sorting being conducted. Any non-  
9 conforming lot would be rejected in its entirety.

10 "The approach which we are suggesting differs from  
11 the approach taken in the specification, in that, (1),  
12 it allows for the sorting of components at various  
13 levels of manufacture, prior to taking samples to deter-  
14 mine conformity; and (2), it decreases the number of  
15 controls utilized in production and thus decreases the  
16 cost of the batteries without sacrificing cell performance  
17 or reliability."

18 Those are three comments from three manufacturers.  
19 I did not ask specifically for any other comments. We did  
20 ask -- and those who are attending, if they would like to  
21 make comments, we certainly would accept them. I wonder  
22 whether T.I. or the Sonotone people would want to say anything  
23 at this particular point? I didn't give them any warning, so  
24 they might feel -- and Eagle-Picher -- pardon me.

25 CARR: Carr, of Eagle-Picher. That was almost like

1 a commercial.

2 I really think that our feelings toward the specifi-  
3 cation have been presented here in the discussion. I do  
4 want to say that we're here to support it, and we want to  
5 help in any way we can to arrive at a higher reliability  
6 battery.

7 BELOVE: Belove, Sonotone. My comments -- like  
8 we've made several comments during the course of the two  
9 days, and our feeling is that the product is important enough  
10 to warrant putting additional effort in.

11 However, as we said before, if it's half an effort,  
12 we might as well leave it as it is and do the best we can  
13 under the present conditions.

14 On the other hand, as I mentioned in a letter to  
15 NASA, we at Sonotone would be happy to work with them in  
16 promoting the state of the art of nickel-cadmium batteries  
17 for space work, because we firmly believe that this will  
18 benefit not only NASA, we as citizens, but we as manufacturers  
19 of a product, of the nickel-cadmium battery.

20 HALPERT: At this point, if there are any general  
21 comments from anyone regarding the subject of how we would  
22 intend to reach these goals that we've discussed in these  
23 specifications, and the problems to be encountered in doing  
24 so --

(No response.)

1           It has been suggested that we open up this dis-  
2 cussion again to the problem of making a ratio measurement --  
3 a negative to positive measurement, and I wonder whether  
4 anybody would care to start off the discussion again along  
5 this line.

6           FORD: I'd be glad to open the discussion. In regard  
7 to this ratio, I'd like to make a general comment; that in  
8 the past three months, from two different sources, failure  
9 analysis has indicated that the capacity of the negative  
10 electrodes after long extended tests is essentially the  
11 capacity that is attained from the positive electrodes.

12           I can specifically refer you to a report that came  
13 out of Battelle, Dr. McCallum is probably aware of the one  
14 I'm referring to, and also recent failure analysis that came  
15 from Crane.

16           I will also indicate two manufacturers' cells were  
17 involved here. And I at this point firmly believe that most  
18 of the cells that we have cycled at Crane in long term test  
19 programs ultimately become negative-limited.

20           The fact that the negative capacity does fade, and  
21 the extent of fading, is a function of the environment and  
22 the condition the cell is subjected to.

23           So the technical justification for a minimum ratio  
24 is certainly within our grasp today. The exact number for each  
25 manufacturer may also vary. But at this point, I think a ratio

1 of 1.5 in most of our applications that we have in mind for  
2 the next 2 to 5 years, and even in the 10-year program, is  
3 certainly going to have to be held up.

4 GROSS: Gross, Boeing. Your remarks must be  
5 interpreted to mean then, that the problem is not one of  
6 determining the ratio; but the problem is one of developing  
7 a better negative electrode. This is where the muscle is  
8 needed.

9 FORD: That would be a solution, but we have to  
10 live with what we have today. In order to live with that,  
11 we have to start out with a minimum amount of excess negative  
12 capacity in a cell to get a certain cycle capability.

13 One other addition I'd like to refer to, is the  
14 work that one of the manufacturers, here today has been doing  
15 for NASA Goddard over the past year. And the need for an  
16 adequate excess negative versus cycle conditions has clearly  
17 been demonstrated in this contract, on which the final report  
18 should be coming out shortly.

19 I think the technology is here, and the information  
20 we need to look at these numbers is currently available to us.  
21 And to me, this minimum ratio of 1.5 for long-term capability,  
22 particularly at temperatures above 160 degrees F is real.

23 RAMPEL: Rampel, with General Electric. The ratio  
24 of 1.5 minimum that you're referring to, Floyd, is I take it,  
25 effective negative/positive ratio as measured in that test in

1 paragraph 10, and not necessarily the actual rated negative/  
2 positive ratio that you might find on -- during electrochemical  
3 cleaning?

4 FORD: Yes, I'm referring to the electrical capacity.

5 RAMPOL: The effective negative to positive ratio;  
6 during electrochemical cleaning it would be expected to be  
7 much higher. Because later on, when you do it in section 10,  
8 as Dr. Scott pointed out before, the cycling history, whatever  
9 it might have been, would have generated inactive cadmium,  
10 which would not be measured during the test in paragraph 10,  
11 where you're measuring the 1.5.

12 FORD: Well, I think if you'll look at the steps  
13 where the samples are taken, that requirement applies to a  
14 finished cell that is to be delivered to the user.

15 RAMPOL: Okay, so that is effective negative to  
16 positive ratio, and actually you would have to go in at a  
17 much higher ratio on the raw plaque -- plates, is what I'm  
18 trying to make understood.

19 GROSS: Gross, Boeing. I would certainly hate to  
20 see the manufacturers achieve this requirement by loading  
21 their present negatives to a higher depth. There has been  
22 work, and I believe Bell has done such work, that would point  
23 to perhaps a lesser loading as being a better way to achieve  
24 the end result.

25 It's not a simple question that can be resolved

1 simply by loading a plate heavier.

2 SCOTT: Scott, from TRW. In that regard, I believe  
3 if we are smart enough we should devise some way within this  
4 testing procedure of measuring the rate of change of negative  
5 capacity during cycling, and therefore, the stability of it,  
6 and give some sort of a specification to that stability over  
7 a number of cycles.

8 I don't know exactly how to do it, but I think  
9 that's the point that you're getting at, too.

10 MC CALLUM: I wanted to ask about this 1.5 ratio  
11 that Floyd just mentioned, and it's in paragraph 10.0, where  
12 it says 1.5 minimum. Whereas this morning we were talking  
13 in paragraph 7.4.3.(g) of 1.3.

14 FORD: There is still a misinterpretation to the  
15 latter paragraph, of 1.30. If you read that paragraph very  
16 carefully, and how it applies to the paragraph above that,  
17 all it says is that the negatives will be discharged a  
18 minimum of 1.3 times the capacity attained on the positive  
19 electrodes.

20 That does not mean you have depleted the negative  
21 electrode of its terminal capacity. The idea there was to  
22 leave precharge in the negative, but additional information  
23 has indicated that this may not necessarily be the desirable  
24 thing at this point, and perhaps it is most desirable to work  
25 with these negatives in a complete discharged condition.



1 HALPERT: Is there anybody that believes that pre-  
2 charge is not necessary? Does anybody believe that pre-charge  
3 is necessary?

4 (Laughter.)

5 BOGNER: Does anybody have any data, showing one  
6 way or the other?

7 SULKES: Sulkes, U. S. Army Electronics Command.  
8 One question is when we talk about ratios of 1.3, 1.4 and  
9 so on, as Dr. Fleischer has pointed out, there is roughly a  
10 20 percent loss. In our present cells, today, we're probably,  
11 I would guess, running ratios of 1.1, 1.05 to 1 as effective,  
12 whereas Floyd now is trying to take it all the way up to 1.5,  
13 which may be perhaps a little bigger job than is actually  
14 justified.

15 And -- I don't know if there's enough data to  
16 actually justify it at this time.

17 HALPERT: Are you talking now about Signal Corps  
18 operation, where you do have some --

19 SULKES: No, even in space, where in other words  
20 your -- most of your cells are, what -- roughly 1.5 -- as  
21 material put in. But when you take your 20 percent loss and  
22 several other factors that occur -- oxidation and so on stand,  
23 your cells that you have tested and done these failure anal-  
24 yses, may have actually started out with very low amounts of  
25 cadmium in excess. And therefore, you may not be really

1 justified in making as big a job as you're actually doing.

2 HALPERT: Any other comments with regard to this?

3 FORD: Yes, I'd like to go a little bit further on  
4 this justification, in saying that cells which have been built  
5 with this minimum ratio -- at least approaching this minimum  
6 ratio, have worked satisfactorily for over a year.

7 In addition to this, the overcharged voltage of  
8 these cells at 0.0 degrees C., under standard test conditions,  
9 not necessarily the ones described in this spec, have remained  
10 fairly consistent throughout the cycle life on a 90-minute  
11 orbit which has completed almost 5500 cycles now.

12 So, what I'm saying is that experience is my only  
13 evidence that I can tell you about.

14 In regard to the gentleman from JPL, we are current-  
15 ly looking at the effect of pre-charge on these cells. I  
16 think I mentioned this to you earlier. And I can tell you in  
17 a very short period, cells that do not have any pre-charge  
18 when they're started on cycling, show a loss of capacity.  
19 But I have to point out, this capacity can be regained quite  
20 readily by simple re-conditioning of the cell.

21 On the other hand, cells that are started on  
22 cycling with a high level of pre-charge show up with high  
23 voltage in hydrogen generation. And this occurred within  
24 600 cycles.

25 HALPERT: Floyd, on the cells that you discharged,

1 were there any differences in the characteristics of the  
2 cells if you didn't discharge them all the way down? In other  
3 words, if you're not worried about capacity, you're just  
4 going 15 to 20 percent depth, is there a significant differ-  
5 ence?

6 FORD: The only difference you can tell, without  
7 completely discharging the cell, is eventually in the over-  
8 charge characteristics. Cells with low level of pre-charge  
9 plates on the negatives, do not show any significant change  
10 in the over-charge voltage -- even at low temperatures.

11 To answer your question -- no, you could not see  
12 the loss of capacity, unless you took it all the way down.

13 HALPERT: I meant was there any other change, other  
14 than that, due to the fact it didn't have any pre-charge?

15 FORD: None that I could put my finger on at this  
16 point.

17 SEIGER: Seiger, of Gulton Industries. I'd like to  
18 ask a question. In those cells in which you fully pre-charged  
19 the negatives, did you notice any change in the positive  
20 capacity as well?

21 FORD: No, none that I would say that were signif-  
22 icant. The positive capacity, following the reconditioning  
23 cycle on all the electrodes, were very uniform.

24 SEIGER: Before the reconditioning, did you notice  
25 anything?

1 FORD: On the initial capacity discharge, the cells  
2 with no pre-charge showed a loss in capacity of approximately  
3 6 to 8 ampere-hours. The cells with two different levels  
4 of pre-charge, one being relatively high -- incidentally, I'm  
5 not saying we fully pre-charged all the cadmium, because we  
6 in no way knew what the total amount of cadmium was in excess  
7 on those cells. The cells that we put some pre-charge in,  
8 showed a slight reduction in positive capacity. But there  
9 were three test samples -- zero pre-charge, four ampere-hour  
10 pre-charge and eight ampere-hour pre-charge.

11 The four and eight ampere-hour pre-charge showed  
12 about the same reduction in capacity with the cycling.

13 FLEISCHER: What was the discharge rate in those?

14 FORD: The cells were being cycled at 25 percent  
15 depth.

16 FLEISCHER: No, but the rate?

17 FORD: C/2.

18 GROSS: Gross, Boeing. I would like to ask the  
19 question, has anybody had unfavorable experience with cells  
20 with high negative/positive ratios? Ford has indicated bad  
21 experiences with cells with low negative ratios and has cited  
22 an example of a case where a cell of high negative ratios was  
23 good.

24 If there are examples where cells have had high  
25 negative/positive ratios which didn't behave well, then this

1 would be important to know.

2 RUBIN: Rubin, T.I. To answer your question, Sid,  
3 first of all, you can't just talk about high negative to  
4 positive ratios, per se. You have to discuss, in addition  
5 to that, the loading level of the plates which includes the  
6 porosity, pore size distribution and thickness of the plate.

7 In certain application, one has to maintain a very  
8 high negative to positive ratio. And this is done most  
9 effectively by loading the positive plate less than you would  
10 normally do. If one maintains the loading levels that you  
11 normally -- and I put that in quotes -- use in space applica-  
12 tions, that loading level, if you increase the negative to  
13 positive ratio by increasing the negative plate loading, per  
14 unit volume or per unit area, then we have experienced high  
15 pressures and a substantial amount of fading in a very short  
16 period of time.

17 I don't have the specific data in front of me, so  
18 I can't really comment on how short a period of time it was --  
19 on the order of 20 cycles.

20 HALPERT: Do you have a comment about that?

21 RUBIN: One additional comment. You will find, I  
22 believe, in the power sources conference, a paper presented  
23 by Dr. Yost and Dr. Pulpert of Texas Instruments, where they  
24 describe some of the effects of heavily loaded negative plates.

CARR: Carr, of Eagle-Picher. In answer to Sid's

1 question, the batteries which we have used in orbiting space-  
2 craft, or that we have furnished for these vehicles, have a  
3 relatively high negative to positive capacity ratio, and it  
4 is our experience that we get quite good results. And in  
5 addition, there were tests run which Dr. Fleischer mentioned  
6 earlier -- the four different manufacturers -- and our cells  
7 were particularly strong in the deep depths of discharge.

8 HALPERT: Are there other comments about negative  
9 to positive ratios, pre-charge, overcharge?

10 Well, is there anything that anybody would like to  
11 present at this time? In a way, we've kind of talked ourselves  
12 out today, but I want to give anybody who wants the last word,  
13 the last word.

14 STEMMLE: Stemmle from Goddard. Floyd's presentation  
15 of the problem leading up to the negative to positive ratio  
16 reminded me of another problem I heard about, a problem which  
17 developed with life of a cell; namely, that they appeared to  
18 dry out. And I just checked back on the electrolyte section,  
19 and I was wondering if we ought to give some consideration to  
20 the optimum amount of electrolyte to optimize cell life.

21 HALPERT: Do you have any comment regarding electro-  
22 lyte, and quantity of electrolyte?

23 CORBETT: Corbett, from Lockheed. Yes. I'd like  
24 to endorse Mr. Stemmle's remark -- I'm thinking back, and I'm  
25 kind of surprised we ignored that whole issue, because if

1 anything is important to the overcharge voltage, it's the  
2 quantity of electrolyte. And it's also the size and the  
3 permeability and so forth of the separator, and the way it  
4 happens to wed out with the electrolytes. So I think that's  
5 the most important thing, perhaps -- next to the positive  
6 ratio -- next to the negative/positive capacity ratio problem.

7 HALPERT: I think it's one of the areas we certainly  
8 want to look at, but we'd like to find out some numbers that  
9 we could put into the spec. We'd like to measure how much  
10 we will put in there, and how much really goes in and is  
11 utilized, and how much is there later on.

12 But I think that's part of the -- not a part of the  
13 specification -- we'd like to be able to put a number into  
14 the specification. We certainly would like to measure what  
15 would go in and come out.

16 Any other comments? Dr. McCallum?

17 MC CALLUM: I would like to make a little commercial  
18 here on behalf of the Columbus Section of the Electrochemical  
19 Society. Next February it is sponsoring a two-day symposium  
20 on battery separators. John Lander of the Air Force now, is  
21 putting the program together. Dr. Reed has a few copies of  
22 the program, and I wanted to make sure you're all invited and  
23 knew about this.

24 HALPERT: I have registration sheets here. Are  
25 there any other comments or questions?

1 FLEISCHER: Jim, will you say what kind of separator  
2 this drying out referred to?

3 STEMMLE: As far as I know, it was a standard line  
4 nicad cell, so I suppose it's a Pelon separator.

5 GROSS: One more question. Gross, Boeing.

6 I would like to invite comments on the subject of  
7 the nickel-plated substrates. The specification prefers that  
8 the substrate be pure nickel. I would like to know what in-  
9 formation is available about the harmful effects of the steel.

10 HALPERT: Well, some reading I had was that iron  
11 does become a contaminant in cells, and at one time -- and  
12 this is quite a long time ago in some of this earlier work,  
13 I think there was a comment as to iron causing ferrites -- ;  
14 that is, the contaminant of iron causing ferrites in the cell,  
15 which had some harmful effect.

16 Now, how that relates to the present situation, I'm  
17 not quite really sure, but just the fact that it did have an  
18 effect in those days is one that we might want to consider for  
19 now.

20 In terms of the nickel actual adherence, in some  
21 of the photos that we've taken -- metallurgical photos that  
22 we've taken of the nickel screen, nickel-plated steel and pure  
23 nickel sheet, we found good adherence of the nickel particles  
24 to those materials. So, in terms of that kind of adherence,  
25 I would say that particle growth is adequate. In terms of



1 what actual problems the iron does cause, that is, at the  
2 moment, still a question mark, outside of that one comment.

3 FLEISCHER: If you want, I can recall some experi-  
4 ments that we did for Fort Monmouth, which had to do with  
5 the effect of iron in the positive plate. And this is in  
6 sintered plate. But this is in the flooded condition.

7 I don't care to extrapolate to the starved condition,  
8 but I'll give you a rough rundown on some of the experiments.

9 We added iron nitrate to the nickel nitrate for the  
10 impregnation in various amounts, and we determined the per-  
11 formance of these plates at various rates of discharge. And  
12 we found at the low iron concentrations -- and I can't give  
13 you the range, whether it was one or two percent of the  
14 nickel -- but we had a linear relationship between the loss  
15 of capacity and the amount of iron.

16 Now, the thing that led me to do this work was the  
17 fact that in those days we used all nickel-plated hardware.  
18 We did use nickel screens. And the iron content of the  
19 electrolyte in these cells was always 0.6 of a part per  
20 million. No matter what we did we always had 0.6 of a part per  
21 million.

22 The next step was to use all pure nickel hardware.  
23 And now what happened, as soon as we started to cycle the  
24 cells the iron content disappeared, and that was it. There  
25 was never again iron over a period of something like 200 cycles

1 at one cycle a day.

2 On the other hand, the ones that had nickel-plated  
3 hardware always ran at 0.6 of a part per million.

4 We analyzed, at the end of the cycling period the  
5 active material from these plates, which had been cycled with  
6 nickel-plated hardware. And the iron content fell right on  
7 a straight line for the loss in capacity for the same number  
8 of cycles.

9 So apparently iron does have an effect on the nickel  
10 electrode when you have a flooded electrolyte.

11 HALPERT: One more comment along that line. Floyd  
12 reminded me of some six ampere-hour cells that we took apart  
13 not too long ago, and I'm not exactly sure of the history --  
14 Floyd might have a better recall of that -- but we found sig-  
15 nificant amounts of iron deposits on the terminal post of, I  
16 think it was the positive electrode, but I'm not certain.  
17 But there was significant deposits of iron.

18 CARR: Carr, of Eagle-Picher. Just for whatever this  
19 information is worth, we ran some tests using some iron  
20 material in the cells. The only real thing -- this was done  
21 on vented cells, rather than sealed cells -- we noticed one  
22 peculiar effect which I can't explain -- I would say I haven't  
23 investigated it -- and that is that after a hot stand, such  
24 as 160 degrees, charged for four days, we saw after this, a  
temporary loss of capacity which was much greater than on cells

1 with pure nickel material in them.

2 This was mostly -- there were a number of different  
3 types of iron introduced, iron tabs, for example, instead  
4 of nickel tabs.

5 SULKES: Sulkes, U. S. Army Electronics Command.  
6 I believe the mechanism that's claimed is that the iron lowers  
7 the oxygen over voltage on the nickel, and therefore your  
8 charge efficiency should drop. And in space cells, particular-  
9 ly, where you may have low charge rates, this could cause a  
10 significant problem.

11 And I believe there's a patent somebody -- it was  
12 beryllium additives or something like that -- to help against  
13 this very problem.

14 THIERFELDER: Thierfelder, from G. E. I just want  
15 to make the observation that the cells on the Tiros satellites,  
16 the Nimbus satellites, have gone well beyond four years.  
17 These are cells having nickel-plated steel substrates. So  
18 they've gone at least four years and they're still going.

19 FLEISCHER: What was nickel-plated?

20 THEIRFELDER: The substrates.

21 HALPERT: Well, if there are no other comments at  
22 this particular point, I would like to thank you all for  
23 coming to these nickel-cadmium session of the specification.  
24 We appreciate your coming great distances, from the west coast  
25 and so forth, and we hope to see -- as a matter of fact, our

1 panel members here, and everybody who did join in the dis-  
2 cussion, and our microphone helpers there on the sides -- we  
3 really needed them.

4 We look forward to seeing many of you tomorrow  
5 on the silver-zinc and silver-cadmium section of the spec-  
6 ification.

7 Thank you very much.

8 (Whereupon, at 4:37 p.m., the meeting was adjourned,  
9 to reconvene tomorrow, Friday, October 31, 1969.)  
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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Goddard Space Flight Center

TECHNICAL/SCIENTIFIC MEETING

on

SPACE BATTERY SPECIFICATIONS

Building Number 3  
Goddard Space Flight Center  
Greenbelt, Maryland

Friday, 31 October 1969

rms 2

P R O C E E D I N G S

HALPERT: I want to welcome you all here this morning to the third session. I want to make a couple of announcements here, if I may. Anyone who has not signed this sheet with the proper address, please do so to make sure you get a copy of the minutes of the meetings. And if you do not have copies of the three specifications on the zinc, the silver and the silver cadmium, since we'll be talking about these today, I'll be glad to make sure you do get one.

Does everyone have copies of these?

As you see our panel of experts has dwindled. I will turn the meeting over to Tom Hennigan.

HENNIGAN: First we would like to cover the Goddard spec for sil-cad cells which is really a combination of Yardney specifications and Goddard specifications. Yardney said they would not attend the meeting. They are in agreement with the specification because it has been used and they only had a few comments on it. Mostly typographical errors.

This spec has been used in part, and as we found problems we rewrote the spec for about the last four to five years, so we have a lot of the numbers for the spec requirements. A lot of it is just to make sure that the process is under control.

rms 3

1 I would say before we used such a specification  
2 we had quite a bit of difficulty in getting flight  
3 quality cells. And now we can buy a lot of several hundred  
4 cells for several satellite programs and maybe we get about  
5 10 percent rejection. It's just rejecting some because  
6 they're a little bit out of capacity or their voltage  
7 characteristics might be a little bit different than the  
8 others, so it has worked out very well.

9 This specification is for a dry cell. After  
10 we receive the cell, we fill it with electrolyte, do all  
11 the formation, sealing and fabrication of the battery.

12 According to the spec, Yardney is the only  
13 supplier, and it says in here some place that they are the  
14 recommended supplier.

15 I want to bring on Ed Colston here who will go  
16 over the spec with you. If you have questions, we will try  
17 to answer them for you. Ed Colston of the Electro-Chemical  
18 Power Sources.

19 COLSTON: There are two things that I think should  
20 be said before we start going into this. One is that  
21 for these specifications we have found it is essential that  
22 you work closely with the manufacturer, get into his plant,  
23 be on friendly terms with him, know his process. And in  
24 some cases we've been up there during manufacture, this  
25 sort of thing.

rms 4

1 Also, if you are military or NASA, there is  
2 probably a D/CAS man at the plant. You might get on  
3 friendly terms with this gentleman too. He is a military  
4 type QC man who stays at the plant and inspects your lot.  
5 And if you talk with him and work with him and tell him  
6 what to look for, we've generally found that they are very  
7 helpful.

8 The next point is that this is the way we buy  
9 the cells. We've done it very successfully for about the  
10 past seven years. If you don't like this or think it is  
11 unnecessary or have your own way of buying it, that's fine  
12 with us. This is not an attempt to say let's all buy them  
13 this way or this the way the industry will do it, because  
14 basically so far Goddard is just about the only purchaser  
15 of secondary spacecraft silver cadmium cells.

16 We would look forward to any comments or opinions  
17 in this session -- philosophy or anything like that -- on  
18 these various sections.

19 Now, on page one, we use these specifications for  
20 buying three, five, ten, eleven and sixteen ampere hour  
21 cells. We then list applicable documents. And then we say  
22 a general requirement is that all these cells be manu-  
23 factured in one production run. We found this very useful.  
24 One production run has turned out to be acceptable when a  
25 run made a half year before that was not acceptable. A satellite



rms 5

1 using a certain production run gets into trouble, if we  
2 have cells from that run, we feel that we can test them and  
3 say something about the satellite battery.

4 Unless otherwise specified, these requirements  
5 in here are 100 percent inspection. We're going to look at  
6 and we're going to weigh, we're going to measure every plate.

7 Now, this does increase costs and time. But it  
8 seems to be worth it. Out of one of our lots that we get  
9 in we can take 20 cells usually, form them, and get 13 or 14  
10 cells for spacecraft batteries.

11 We've known other groups that in order to get --  
12 what was it -- 18 cells, they had to use a lot of 50 to  
13 60 cells. So, by increasing the QC requirements to 100  
14 percent inspection we have reduced the number of cells  
15 that needed to be bought or expended.

16 All right. Under components, 3.2, the first one  
17 is a general type statement about the stock electrolyte solu-  
18 tion. This comes into the factory at about 45 percent  
19 solution.

20 On the next page we have the chemical require-  
21 ments. The first one is left blank, the potassium hydroxide  
22 concentration by weight because although it is usually 40  
23 percent solution, this can vary if you want something special.  
24 We just say plus or minus one percent.

25 Then for the potassium carbonate and the chloride

rms 6

1 and the carbonate and the iron, we have listed specifications.

2 Then for the silver we have listed density,  
3 particle size and electrical utilization. Now, on the  
4 electrical utilization I am told that this 2.6 grams per  
5 ampere hour is a very low figure, that it's very easy to  
6 meet this figure, and it possibly should be raised.

7 By the way, that we know of we haven't had trouble  
8 with the silver powder or the silver plates particularly.  
9 Now, for the cadmium oxide powder, the cadmium oxide  
10 powder shall be free flowing --

11 FLEISCHER: That's the point I wanted to ask  
12 about. I have never seen free flowing cadmium oxide powder.  
13 For example, you can't screen it. You have to use special  
14 devices for doing it. It will not pass the Hall test  
15 which is used in powder metallurgy. I've never seen any  
16 free flowing cadmium oxide.

17 COLSTON: Well, we've had two groups of cadmium  
18 oxide powder that we've seen. One type was pourable. The  
19 other type tended to clump together and stick together  
20 as though it was damp. There seemed to be some sort of  
21 moisture or something in it that was causing it to stick  
22 together.

23 FLEISCHER: Well, I've seen all kinds of cadmium  
24 oxide powder because it is used directly in the pocket type  
25 plate. And it is not free flowing. It has to be pushed.

rms 7

1 And it will not pass the Hall test which is the standard  
2 for free flowing powders. It is even worse than carbonyl  
3 nickel powder which will also not flow. So, I was sort of  
4 surprised when I saw that expression.

5 I don't know, maybe it has changed in the last two  
6 years, but I've never seen any free-flowing cadmium oxide  
7 powder.

8 HENNIGAN: Well, it is weighed out into a cup  
9 when the girl pours it into a mold, and it seems to flow  
10 out of the cup evenly. As long as we don't run into a  
11 processing problem with it. As we mentioned one time it did  
12 start to clump on us. The girls could use it, but they had  
13 a heck of a job making these plates.

14 FLEISCHER: I'm talking from the experience of  
15 going through this of trying to find out how to measure  
16 the properties of cadmium oxide for the pocket type nickel  
17 cadmium production. And, for example, I thought at first  
18 well this is a matter of very small amounts of moisture.  
19 So, we dried them at different temperatures over a long  
20 period of time. No, it didn't make any difference.

21 I see your point that you use it for a special  
22 thing where you can label it and spread it. I don't know  
23 whether that would have any relationship to free flowing in  
24 the ordinary sense of the term in which it's used in powder  
25 metallurgy, we'll say, where it's a very important property.

rms 8

1 Well, maybe what you want to do -- it shall not be clumped.

2 I mean this is what you're saying.

3 HENNIGAN: Right.

4 FLEISCHER: I would interepret this to mean that  
5 it can pass the Hall test within a reasonable flow.

6 HENNIGAN: But on the test, if it's usable, the  
7 girls can use it there. That's it.

8 COLSTON: This is similar to this next statement --  
9 brownish red in color. We've been up to the -- we have  
10 seen cadmium oxide that they wanted to use that was gold.  
11 And we had never seen it before-- about the color of the  
12 fringe on the flag over here.

13 And we took it. We did a chemical analysis of  
14 it -- no different. It seemed to work in plates and what-  
15 not, but it's different. And the reason why we say things  
16 like free-flowing and specify a color is because we have  
17 seen different cases, but this is the way it normally is  
18 when we know it works. And if something comes in that's  
19 purple with gray spots, it may be great cadmium oxide, but  
20 we want them to have to call us up at least on the tele-  
21 phone and ask our permission before they use it.

22 HENNIGAN: Well, what we normally do in these  
23 cases is we'll have them make us a few cells and cycle  
24 them as many times as we can without holding them up too  
25 long. And this is a very small production with them. It's

rms 9

1 almost a nuisance to them, but we have to do these things.

2 FLEISCHER: Well, I was just calling attention to  
3 the term free-flowing in here which is not the normal use  
4 of the word, because cadmium oxide is simply not free-flowing.  
5 If you look at it, have electron photomicrographs made,  
6 which I had AS&R who supplies most of the cadmium oxide  
7 from their Denver plant, every particle in that thing has  
8 a cubic shape. It's sort of a remarkably uniform product,  
9 and it's very difficult to see why this stuff doesn't  
10 flow, but it doesn't.

11 And then the other thing I'll say is we were  
12 never able to match colors of the drums, but this didn't  
13 make any difference. Now, the reason for this is that the  
14 free cadmium content -- if you analyze cadmium oxide, the  
15 cadmium content is always greater than corresponds to CDO,  
16 the chemical composition CDO.

17 Once in a while you find some free metallic  
18 cadmium, but this is not really the source of the excess  
19 cadmium, it's the fact that it's an oxygen deficient material,  
20 so you just don't get the same composition in every grain,  
21 so you have differences in color. Well, if everybody under-  
22 stands what you mean, all right. But this is not the  
23 normal use of this term.

24 HALPERT: Ed, I'd like to ask a question about  
25 the term "electrical utilization." How is it determined

rms 10

1 here? And is this the proper place for it? Or should it  
2 be determined downstream further?

3 COLSTON: This spec is written such that in the  
4 front part of it you have what we want, the in product on  
5 each state. In the back of the speck is where according to  
6 the form we put the tests and what-not.

7 Now, I think this electrical utilization says in  
8 effect the tests will be done in accordance with standard  
9 manufacturer procedures, so what in effect it says is do it  
10 the way they usually do it. I do know that they make lot  
11 tests. They test each lot of silver as it comes in.

12 HALPERT: They make plates out of it first and  
13 determine whether it reaches this 2.6 grams per ampere hour.  
14 Is that it?

15 COLSTON: I don't know the exact test.

16 HENNIGAN: Yes, they make cells, 10-ampere-hour  
17 cells and test them.

18 COLSTON: Any more comments?

19 (No response.)

20 The particle size then we list .95 microns to  
21 not greater than 2.5. About a year and a half ago we had  
22 some trouble, and we did notice the particle size of the  
23 cadmium oxide used in the plates had changed. And the  
24 manufacturer of the cadmium oxide had changed, and so we  
25 put this in so that at least this is one more thing that

rms 11

1 was used when the cells acted like they should act. And  
2 there seems to be a problem in getting suppliers of cadmium  
3 oxide in this range.

4 HENNIGAN: I would like to comment on that. The  
5 only way we can get the cadmium oxide this way is the  
6 company that makes it, American Smelting and Refining,  
7 every once in a while they make a lot and they send a sample  
8 to Yardney, they check it. If it's within spec, they buy  
9 it. If not, they don't buy it. And they buy a lot for about  
10 a year. That's the only way we can get it now.

11 CHREITZBERG: How do you check particle size?

12 HENNIGAN: They use a Fischer instrument. On this  
13 type of thing it's up to the manufacturer to check it the  
14 way he normally does. And we know he has this instrument  
15 and he uses it.

16 CHREITZBERG: Do you feel the different labs  
17 can duplicate it with the same type of instrument?

18 HENNIGAN: I really wouldn't know. If you want to  
19 make a note of that, maybe we'll get to it later.

20 COLSTON: He does send us out data -- the manu-  
21 facturer -- on his measurements of particle size.

22 Any further comments?

23 (No response.)

24 All right. On the cadmium oxide powder require-  
25 ments, table II, Yardney tells us that the last item, the lead,

rms 12

1 should be changed to .01 percent maximum.

2 GROSS: Ed, which of these impurities have caused  
3 you the most trouble in the past? And which should be  
4 looked at most carefully?

5 COLSTON: I'd say the impurity that has caused  
6 us the most trouble is in the next section in the separator,  
7 the wetting agent. Of course, some things in here such as  
8 the iron and what-not you wouldn't want a great deal in your  
9 cell because they tend to poison it, but I don't think  
10 we've noticed anything.

11 Okay, Separator materials.

12 Under woven or non-woven nylon. Under thickness,  
13 the 3.0 plus or minus .1 mils under 3.2.4.1 (a) should  
14 be for a non-woven nylon 4 to 7 mils one type, and then the  
15 other type is 3 to 5 mils.

16 Under the woven nylon we are told it runs 2.2 to  
17 2.8 mils in thickness. Now, the wet-out time, this is  
18 an item we have no standard for here, it shall be at least  
19 so many hours or not greater than so many hours. The  
20 manufacturer does measure this, and I would say the thing  
21 to watch out for would be if on these tests he got an  
22 unusually fast wet-out time. To me this would imply a  
23 wetting agent, something like this. I would question the  
24 separator lot.

25 Generally nylon does not wet very well. Organic



rms 13

1 extractables: This is a test -- we give a method in the  
2 back, things like wetting agents, lubricants shall not be  
3 greater than -- you can change that to two percent by weight.

4 Now, we've had it pointed out to us that the sol-  
5 vent mentioned can absorb water and possibly throw your  
6 measurements off, but the test in practice seems to work,  
7 and we've caught a lot that was suspicious, and we have  
8 passed other lots.

9 Then the next statement, "Wetting agents. The  
10 Separator material shall not contain any wetting agents."  
11 Now, the reason we have two different statements, in (c)  
12 we hope to catch a wetting agent and several other things.  
13 In (d) -- that was put in because our chemist told me  
14 that there are some wetting agents that a tenth of a percent  
15 would interfere with your cell operations. And so just to  
16 be on the safe side just say that no wetting agents will be  
17 allowed.

18 Okay. Are there any comments or questions or  
19 anything on this?

20 SULKES: Sulkes, Army Electronics Command.

21 I just want to jump back to the cadmium powder  
22 requirements. On your impurities, rather than affecting  
23 the cell electrical performance you do have I believe  
24 magnetic requirements, and do you feel that these particular  
25 impurities should be looked at for that reason rather than

rms 14

1 the electrical requirements, particularly things like  
2 nickel and iron?

3 COLSTON: Theoretically, yes, I think that on  
4 the nickel and iron that you would have to have a very  
5 significant amount, one percent probably and up, before  
6 it starts affecting the magnetic ability of the cells.  
7 And on that the cells we have ordered to these specs, by  
8 the way, are with no current flowing. As measured here,  
9 it's less than .2 gamma at 18 inches, which is just about  
10 the accuracy of our test range here.

11 HENNIGAN: This batter is essentially non-  
12 magnetic. Yardney can't check it. They don't have the  
13 instruments, so we have to check the cells when we get them.  
14 Now, if they're built according to this, we feel they'll be  
15 nonmagnetic and pass the test.

16 HALPERT: Ed, I'd like to ask, back in 3.2.3  
17 where the chemical analysis is done, does the company  
18 specify to the AS&R these chemical analyses? Do they actually  
19 check it?

20 COLSTON: Let's see. The chemical analysis  
21 should be probably as it's bought.

22 HALPERT: That's made to the spec.

23 COLSTON: Yes.

24 HALPERT: How about in the separator materials,  
25 do they check these values, that is the battery company, or

rms 15

1 do they impose a restriction on the separator company?

2 COLSTON: They do check -- let's see, wet out  
3 time. This spec calls for them to perform a test for  
4 organic extractables. Wetting agents would be a sort of  
5 thing that would be put in there, order forms from the  
6 supplier.

7 COHN: Cohn, NASA Headquarters.

8 Coming back to this magnetic properties question,  
9 it seems to me I remember talking with the people from GE  
10 who deliberately add iron to the cadmium plate, and I  
11 don't remember what the actual percentage is, but I think  
12 it might go as high as 10 percent, and will reduce this to  
13 metallic iron. And yet apparently that passes the magnetic  
14 test here, so I imagine that what is governing here may  
15 well be the particle size rather than the amount of iron.  
16 It is well known that if the particle size is below a  
17 certain threshold size that the magnetic properties decrease  
18 drastically, and apparently what happens is that the iron  
19 is finely enough divided -- or cobalt for that matter, if  
20 it is present, or nickel -- that the magnetic properties  
21 are much less than you would expect of one big lump.

22 COLSTON: Any further comments?

23 BOGNER: Do you use the same separator material  
24 in the silver-cad as the ni-cad? And if you do, why wouldn't  
25 you have the same spec?

rms 16

1 HENNIGAN: This is calendered material. These  
2 materials are calendered. The ni-cad materials are called  
3 maximum loft, what it means is calendered on a hot roll.

4 SCOTT: What about the other specifications though  
5 for resistivity, electrolyte retention, air permeability and  
6 the various kinds of things that were discussed the other  
7 day in connection with nickel cadmium cells?

8 COLSTON: These cells are flooded. WE assume that  
9 we have no gas recombination. We don't care if it takes a  
10 week, generally when we add electrolyte it wets very nicely  
11 in about 72 hours. If it took an extra day, we wouldn't mind.  
12 So, as far as allowing gas to pass easily through it and  
13 how quickly it will wet with a flooded cell such as this,  
14 it doesn't seem to matter.

15 HENNIGAN: Let me make a comment. There's one  
16 material we have used. You can use Pellon, the non-woven,  
17 or the woven. The woven nylon doesn't wet at all, and it  
18 works fine in the cell. I mean it won't wick(?), that's a  
19 term for not wetting.

20 CHREITZBERG: Chreitzberg, ASB.

21 I'd like to ask a question. In the thickness,  
22 especially in the dry thickness, can you specify the  
23 pressure in psi that is used by the measuring instrument.  
24 In paragraph 4 I believe you mention a Cady gage, is this  
25 one psi pressure? This is not critical for the woven

rms 17

1 materials, but it will affect the results tremendously for  
2 the non-woven materials.

3 HENNIGAN: It is probably a good point. We should  
4 specify the weight of these.

5 COLSTON: Further comments?

6 (No response.)

7 All right. Should we go on to silver treated  
8 cellophane?

9 Now, since this is the way Yardney manufactures  
10 the cells, we have it like this. But as to whether silver  
11 treated cellophane is an improvement over straight cello-  
12 phane seems when you ask the manufacturer to depend on  
13 whether they use it in their product or not. But since  
14 Yardney has it in their product we have a specification on  
15 it.

16 We have dry thickness, moisture content, resistance.  
17 That resistance shouldn't .014 ohms per square inch. It  
18 should be .014 ohms inch square.

19 Then silver content. Wet thickness, we do have  
20 some results there. I don't know if you are familiar with  
21 a device developed by Mr. Hennigan here for measuring the  
22 swelling of a separator. Basically it is a rubber bladder  
23 sort of thing inside a frame. You put your separator in  
24 it. You have a caliper head against the side. You take a  
25 measurement, take a reading. Then you add electrolyte,

rms 18 1 allow the cellophane to swell. The bladder expands. Then  
2 take another reading with your caliper head, and you get  
3 your increase in your swelling of the separator.

4 Generally these separators triple their width  
5 roughly upon addition of KOH.

6 Visual inspection -- I think these are obvious.  
7 This is an inspection which is performed.

8 Any comments on this area? Dr. Fleischer?

9 FLEISCHER: C-19 is a proprietary material. And  
10 the only way you can get any idea of whether you can make  
11 it -- I mean we're talking suppose I want to make it -- I'd  
12 have to go to the patent.

13 And I'm positive from having read that patent  
14 that I wouldn't be able to make it. So, now what do we do.  
15 This is a general thing. We've specified something that is  
16 a secret for which there's no clearcut way of knowing how  
17 to make it. And you put that in here. This sort of negates  
18 the whole specification.

19 COLSTON: No. This specification, as I've said  
20 before, is written directly at Yardney. It can be modified  
21 for other suppliers. By the way, I have bought silver  
22 cadmium cells from other cell suppliers with the silver  
23 treated cellophane.

24 FLEISCHER: Well, there is another patent. That's  
25 why I brought it up. They use a sodium borohydride reduction.

rms 19

1 And it's spelled out quite clearly. Well, I think then you  
2 will have to put in a statement here that where it refers  
3 to a thing like that that you will accept a substitute which  
4 has been qualified.

5 COLSTON: If I was using this specification to  
6 order silver cadmium cells from another manufacturer, I  
7 would have to drop certain areas and rewrite them. Yes,  
8 definitely.

9 FREISHER: Well, I think under the circumstances  
10 I would say so in the specification.

11 RYDER: I agree with that, with Dr. Fleischer. I  
12 am very confused. Maybe I don't understand the intention  
13 of this. Is it to review a proprietary Yardney specification  
14 period? Is that the intention? Or is it to attempt, as  
15 Dr. Fleischer has indicated, to work out where compatible  
16 with your objectives a specification which will not be a  
17 Yardney specification but which will truly be a Goddard  
18 specification which might possibly be capable of being met  
19 by people other than a proprietary source. I think this goes  
20 to the key question of the whole discussion.

21 COLSTON: This document -- we do buy silver  
22 cadmium cells from many manufacturers for evaluation. At  
23 the present time, based on history, experience, characteris-  
24 tics, the only manufacturer we fly is Yardney. This may  
25 change in the future.

rms 20

1 On buying our evaluation cells for evaluation, to  
2 look at them, send them out to Crane to test them, we will  
3 change this. The intent of this document was to assemble  
4 all the various specification we use for having spacecraft  
5 quality flight cells, silver cadmium cells, manufactured for  
6 space flight use.

7 Now, this silver treated cellophane business is  
8 in here. It is the data and what-not from the Yardney  
9 type of process. We go to a manufacturer and we want to  
10 buy some silver cadmium cells and they don't use silver  
11 treated cellophane, we drop it. If they get it in there a  
12 different way, we'll look at some of our data. We'll put in  
13 some -- personally I'd leave the visual inspection in there.  
14 I still wouldn't like tears, fingerprints or scratches in it.  
15 But we would use this for their -- we would modify this  
16 for their process. But basically this is written for  
17 space flight use for space cells.

18 When we get two manufacturers or three manufacturers  
19 of this type of cell, yes, this will have to be modified.

20 FLEISCHER: I think you can get around the  
21 objection by taking out the words "C-19." You have silver  
22 treated cellophane(C-19). So, if you take out the word  
23 "C-19," then what you're telling me is if I build a battery  
24 with silver treated cellophane which meets this requirement,  
25 I can pass the test.



rms 21

1 COLSTON: No, you can pass this section.

2 FLEISCHER: Yes, but I can't if you call it C-19.

3 COLSTON: Okay. All right. I think that's valid.

4 SEIGER: Seiger, Gulton Industries.

5 I think similar considerations would have to be  
6 given elsewhere, for instance, you spell out the cadmium  
7 oxide powder. There are other ways of making negative electrode  
8 You can start with cadmium hydroxide as well.

9 COLSTON: Further comments?

10 (No response.)

11 All right. The cell cases and covers.

12 We have a visual inspection and then some  
13 dimensions. The dimensions ~~are~~ not given, just the tolerances.  
14 The dimensions will be dependent on the case design and  
15 the cell size.

16 Comments?

17 READ: Read from General Electric.

18 Wouldn't some sort of a material definition be  
19 appropriate in there? :

20 COLSTON: We have a statement to the effect of --  
21 let's see what is it -- Bakalyte(?) or equivalent, C-11.

22 READ: Okay. Thank you.

23 COLSTON: Then we have an internal pressure test.  
24 We have the operator guess at what the burst pressure is.  
25 He applies half of this pressure for five minutes and looks

rms 22

1 for evidence of leaking or cracking, and then after the  
2 five-minute period he raises the pressure of the cell  
3 case until it does burst and records the data. Now, this,  
4 of course, cannot be performed 100 percent. This is a  
5 sample sort of thing.

6 Any questions or comments?

7 Grids. All grids shall be expanded metal number  
8 one mesh. Now, this is optional. This is a design criteria.  
9 I personally feel that you could improve the high rate  
10 characteristics of this cell by having a finer grid on the  
11 cadmium plate.

12 Usually, though, these cells come with a one  
13 grid or a one zero. Then we say we want it 99.9 percent  
14 pure silver.

15 Comments, questions?

16 (No response.)

17 All right. Miscellaneous components. And this  
18 is what has been described as a motherhood statement. Bas-  
19 ically we don't want anything to be susceptible to KOH  
20 corrosion, and we also want everything to be non-magnetic.  
21 And here again to show that it is non-magnetic they would  
22 probably have to send samples here, and we'll run tests on  
23 them out at the magnetic test range.

24 Comments or questions?

25 FLEISCHER: I want to go back to the silver content.

rms 23

1 That's paragraph 3.2.6.2. There is a federal specification  
2 or a military spec, and I've forgotten which one. I think  
3 it's the military. It is for silver. Why not use it?  
4 I mean specify the silver to be something for which there  
5 has been written a government specification? I just don't  
6 remember the number right this moment, but there is one.

7 RICHARDSON: Richardson, Marshall.

8 What is the specific criteria for being non-  
9 magnetic. In your application do you require your batteries  
10 to be non-magnetic. Is this the reason?

11 COLSTON: Yes. This is one of the main reasons  
12 for using silver cadmium cells. you have a small scientific  
13 satellite such as built here at Goddard. They've got a  
14 magnetometer or something on board, an instrument that  
15 would be affected by the magnetic characteristics of the  
16 battery, so you build a non-magnetic battery.

17 RICHARDSON: If we were to consider using these  
18 maybe in a reusable space booster or something like this,  
19 this would not be a criteria which would affect us.

20 COLSTON: No

21 UCHIYAMA: Uchiyama, JPL.

22 Can I assume the statement of non-magnetic to  
23 mean really magnetic stability rather than non-magnetic?

24 HENNIGAN: These can't be permed(?) up. They  
25 put them in a rather strong field, and they still will not

rms24

1 pick up any magnetic property. And they're stable in the  
2 earth orbit, going through the magnetic field and so forth.

3 COLSTON: And It's not absolutely non-magnetic  
4 either. What is meant is that we would like it to be such  
5 that we just can't measure it here.

6 There is another -- it hadn't occurred to me --  
7 advantage of silver cadmium cells. They do have a relatively  
8 short life to nickel cadmium, generally on a typical IMP  
9 type mission we guarantee them a year, and they usually  
10 last two, given the correct orbit.

11 But we do generally fly at -- considering the  
12 total amount of watts in the battery, not the amount that  
13 is used -- we fly at a higher watt hours per pound than  
14 the typical nickel cadmium battery. I think RAE, for  
15 instance, flew, considering the total capacity, at about  
16 8.7 watt hours per pound.

17 The IMP-I battery we've got over here will fly  
18 at about 13.8 watt hours per pound. This is considering the  
19 total watts in the battery, so we've got a gain of five watt  
20 hours per pound. Although in two years the IMP-I battery  
21 will be dead and the RAE will probably still be working.  
22 So, this is one other advantage.

23 GROSS: Gross, Boeing.

24 On dimensions I would think that the radius would  
25 be an important dimension to include. The sharp internal

rms 25

1 radiuses will help promote cracks and sharp outside  
2 corners make it difficult to install in packages.

3 COLSTON: There is a statement in here, isn't  
4 there, on the curvature of the edges.

5 HENNIGAN: Do you mean the case or the plate?

6 GROSS: The case.

7 COLSTON: Yes, if it is not in here, that's a good  
8 point.

9 REED: Reed from Battelle.

10 One more question before we go on. In all the  
11 other specifications here for purity, you specify purity  
12 except for the silver powder. I do not see a purity  
13 requirement on the silver powder. Is that an omission, or  
14 is there a reason for doing this?

15 COLSTON: Let's say what do we say here? There  
16 is no specification on the silver powder.

17 HENNIGAN: I thought there was.

18 COLSTON: I would assume we imagine that it is  
19 pure silver powder. But we don't have a table in here.

20 HENNIGAN: Some of the information here is some-  
21 what proprietary to Yardney, and we couldn't put it all in.

22 COLSTON: Sometimes extras are thrown in. Perhaps  
23 it would be a good idea to have a table in there and give  
24 a certain percentage to a magic ingredient and then list  
25 some possible impurities for the silver powder and this sort

rms 26

1 of thing. Althought the trouble we have had so far has  
2 not been with the composition of the silver plate. We've  
3 had trouble with the cadmium plate, but not with the silver.

4 CHREITZBERG: Chreitzberg, ASB.

5 Does this mean that the silver powder contains  
6 palladium or lead or some other additive?

7 (Laughter.)

8 COLSTON: Any further comments?

9 FLEISCHER: Both \_\_\_\_\_ and  
10 Englehart have standard specifications for purity of the  
11 silver. And they grade their various powders, and I'm  
12 sure you can get their analyses as to what their specifi-  
13 cations are.

14 I know I have them somewhere, but I just don't  
15 carry that in my head, but you can get them from both.

16 HENNIGAN: I will answer your question, Gus,  
17 we have used cadmium oxide mixed in with the silver powder,  
18 which they claimed was for reversal protection, but I  
19 don't think it did that much, plus we balance the cells  
20 so well that we're pretty sure that we aren't going to  
21 reverse.

22 COLSTON: Yes, I think there should be something  
23 in there on the silver plate.

24 Oh, on the dimensions of the cell case, one  
25 thing that we as a user do usually, when we do start getting

rms 27

1 data on the cell, we add up the total thicknesses of  
2 the number of silver plates in it, the total thicknesses  
3 of the number of cadmium plates in it, add in all the  
4 various nylon separators, take the total thickness of all  
5 the layers of cellophane, multiply it by three -- that  
6 would be roughly its expanded thickness -- add up all these  
7 widths and make sure it's less than the internal width of  
8 the case.

9 We have had a problem with too much material in  
10 too narrow a case. This is a little check we do.

11 BOGNER: Do you have a draft on the case, or  
12 do you measure it at the narrowest spot or how?

13 COLSTON: These are the design dimensions of the  
14 case. We get this data.

15 BOGNER: I mean you have a draft angle on the  
16 case. It's not a perfectly symmetrical case?

17 COLSTON: Yes. It is probably what -- halfway  
18 down?

19 HENNIGAN: This is the average dimension at the  
20 center.

21 COLSTON: Which would be halfway down. We found  
22 out it's pretty difficult to make a case without a draft.  
23 We have one with minimum draft now.

24 FLEISCHER: The cases actually don't have much  
25 draft inside. I think for the size you're using here it

1 would be about 1/1000th of an inch.

2 HENNIGAN: No, it is more than that. I would say  
3 it is around 7 or 8 thousandths. On a case about three and  
4 a half inches high.

5 FLEISCHER: Well, the Nike missile case doesn't  
6 have that much draft.

7 SULKES: These typical cases run about 8 mils  
8 per inch. If you get down to 2, you're doing pretty good.

9 HENNIGAN: We have been developing a case that  
10 has essentially no draft. Bob Steinhauer, what is the  
11 draft on those cases?

12 STEINHAUER: Two-tenths of a degree compared to  
13 a \_\_\_\_\_ practice of about five-tenths to one  
14 degree per wall. This is about compatible with what  
15 Art Sulkes mentions. Is that mils per running inch?

16 SULKES: Yes.

17 RYDER: I asked if it was C-11.

18 SULKES: I said that it could be C-11. It could  
19 be ABS or other material of that type. It doesn't seem  
20 to matter too much.

21 CHREITZBERG: Would it not be well to specify  
22 the pressure and psi that you want to have exerted on the  
23 cell pack when it is in the jar. You get close to it in  
24 3.2.4 where you specify the wet thickness of separator  
25 cellophane being four pounds per square inch. Isn't this



rms 29

1 really what you're trying to achieve by the summation  
2 of the thickness of all components?

3 COLSTON: There's very little pressure as such,  
4 because we're trying to get the total swollen thickness  
5 of everything after you add the electrolyte still to be less  
6 than the internal width of this cell case.

7 HENNIGAN: It's pretty hard to specify internal  
8 pressure here if you've got a taper and then you've got a  
9 U-fold that's bunching up in the bottom. Do you do this?

10 CHREITZBERG: We do not, but we find it is critical.

11 COLSTON: Comments?

12 VOICE: We better move along faster.

13 COLSTON: Okay. Flexible parts. Solder and  
14 fluxes. Terminals. Cements. This Plexiglas Cement is for  
15 if you have the manufacturer seal the header to the case.  
16 Pressure gages, if ordered on the cells. Then we come to  
17 subunit assembly.

18 Cadmium oxide mix. Then we have cadmium oxide,  
19 silver powder and PVA percentages. Here again, a different  
20 manufacturer that has a different recipe, these would be  
21 changed.

22 Electrode mix weight. And then we have percentages.  
23 Dimensions. Visual inspection. Then the electrode  
24 weighings. We have every plate weighed and recorded. And  
25 we are sent the data on every plate that goes into our cells.

rms 30

1 We are even sent the data on the rejects that didn't go  
2 into our cells.

3 And, by the way, this is another check. There's  
4 usually a -- for a typical process there's a certain per-  
5 centage of rejects of cadmium plates, certain percentage  
6 of rejects of silver plates. The cadmium usually is almost  
7 twice the reject rate of the silver plate. But if the  
8 manufacturer is running along at a certian percentage  
9 rejects and you're getting the data. Then on another run  
10 the percentage rejects is up or down, say, five percent,  
11 personally, I would go and find out why.

12 SULKES: A comment. The silver powder that you  
13 call out in the negative electrode is that required to  
14 meet the same requirements as the positive electrode  
15 powder? And is it intended to be the same powder?

16 COLSTON: I am not sure.

17 HENNIGAN: We are not sure about that.

18 SULKES: Actually, is there any requirement on it  
19 at all?

20 COLSTON: All I can say is it is a good point.

21 FLEISCHER: How does silver powder provide over-  
22 charge protection?

23 COLSTON: We dn't overcharge these cells. We  
24 don't even fully charge these cells.

25 FLEISCHER: Didn't you make a statement that that's

rs 31

1       why it was added?

2               HENNIGAN: At one time we used to put cadmium  
3 oxide into the silver electrode. There was a claim and  
4 there is a patent that this will provide overcharge  
5 protection. We really never thought it worked that way.

6               FLEISCHER: So this silver powder is --

7               HENNIGAN: That's for conductance.

8               HALPERT: Can I make one comment? Yesterday we  
9 talked a lot about traceability and making sure we do have  
10 traceability and also statistical methods to make sure  
11 that in sampling we have the proper mats(?). And none of  
12 that is mentioned in here. I just would make the general  
13 comment that maybe in the consideration of changes you  
14 might want to use the Mil specs in terms of sampling and  
15 also make some statements with regard to traceability of the  
16 basic materials, namely PVA, the powder, the silvers, every-  
17 thing that's used.

18               COLSTON: We do have a statement in the beginning  
19 on the standards we call on NPC-200-3 which does have I  
20 believe traceability requirements in it.

21               GREEN: Green, Martin.

22               I was interested in a statement you just made  
23 that if a particular order should run greater than, say,  
24 the average percent rejects you saw in the past or less than  
25 the percent rejects, on what basis would you highly question

rms 32

1 less rejects?

2 COLSTON: Either way. I would say that some-  
3 thing had changed. It is entirely possible it could be  
4 for the better, but I'd like to know what it was.

5 NIETZEL: Do you have an internal specification on  
6 what rejection rate would then reject the whole lot?

7 COLSTON: No, we don't. See, this is not a  
8 sample basis where you can say if on our sampling of ten  
9 percent we'll reject the whole lot. This is an individual  
10 basis.

11 NIETZEL: A sorting operation.

12 COLSTON: Yes, and we're getting data on the  
13 accepted plates and the rejects.

14 Are there further comments or questions?

15 (No response.)

16 Let's see, then we have requirements for the  
17 negative electrode dimensions. We threw in here to make  
18 sure that this manufacturer uses half plates on the ends of  
19 the plate stack, that we had an understanding that he would  
20 color code the lead in wires so that we could visually look  
21 at the cell and say yes there are half plates on the end, and  
22 he didn't slip any into the middle of the stack. But we  
23 got one order on which it wasn't true, so now we've got to  
24 the fact that it shall be color coded.

25 On the positive electrodes, here again, we've got

rms 33

1 dimensions. And if you will notice on all of these the  
2 thicknesses of the plates, or the tightest(?) dimension.  
3 And then we say basically that we will get data on the  
4 weight. We've got lead forging.

5 There was a comment that Yardney wants the  
6 thickness of the plate and lead at the welded joint --  
7 can exceed the plate thickness by not more than .004 inches  
8 maximum.

9 Adhesion. Visual inspection. Then a general  
10 visual inspection of the plate itself. And within the  
11 past year or so, we've seen another type of defect that  
12 should be put into this visual inspection that the silver  
13 plate shall be free of greasy fingerprints.

14 Then the rolled silver strip sort of specification.  
15 Now, this can be modified to accommodate other procedures  
16 for making the silver plate. Then we have the separator  
17 system describing the wrapping system, and it asks for five  
18 wraps of the separator. And personally -- this is my opinion  
19 I agree with this, there seems to be some sort of -- one 2-  
20 mil thick cellophane separator does not seem to stop silver  
21 as well as two 1-mil thick separators right together.  
22 There seems to be something associated with the boundary  
23 or something. So, this is why I do agree with the five  
24 wraps.

25 Any comments?

rms 34

(No response.)

On the unit assembly, cover assembly, they have visual inspections, terminal dimensions. Some of these say basically in accordance with the contract. Cell assembly. It describes the wrapping procedure listed previously. We don't want excessive bends in the leads and tabs.

Terminal soldering, describing run-over and the amount or how much they can play around with the cell plates aligning the lead-in wires into the barrel terminal.

Terminals shall be free of potting. The terminal barrel tubes shall be wiped clean. It was noted that you get an orange peel effect on top of the solder if you don't wipe the barrel clean. And when you do, you don't get it. Now whether this makes any difference I don't know, but I like to see a very nice solder job, solder with a clean surface, so this is why that article is in there.

Soldering heat shall not discolor the terminal, which in some silver cadmium cells they put way too much heat to it, and they do burn the gold plating slightly which is on the terminal.

Do you have a comment.

GROSS: Yes.

Ed, these specs suggest that the manufacturer can choose either woven or non-woven nylon. Do you have a

rms 35

1 preference? I would suggest that the buyer select either  
2 woven or non-woven nylon. They both seem to work as well,  
3 and there seems to be a smaller chance of getting your  
4 wetting agent with a woven nylon. So, personally I would  
5 get woven nylon.

6 GROSS: So you are using woven mostly?

7 COLSTON: Other comments?

8 (No response.)

9 Terminal potting. This I do think is important  
10 to have a lot of inspection on how the -- in this case  
11 the bond master is applied to the wires to keep the  
12 electrolyte away from the solder, to cover voids. It's a  
13 girl there that's doing it, but you want to make sure that  
14 she is doing it. I have seen cells -- I've been to the  
15 plant and seen our spacecraft cells being made here and  
16 right next to it was a lot for another area, same type of  
17 cells, but yet just by looking at them, looking at how the  
18 potting was done, the quality of the plates, there is a  
19 difference. And it is important that you have this sort  
20 of visual inspection. And on this terminal potting we must  
21 had a case of where they've got the battery on the space-  
22 craft, and it's upside down.

23 And if there are voids and holes in that what we  
24 call blue goo(?) potting, bondmaster, that electrolyte is  
25 going to be at the goldplating. And if there is a void in

rms 36

1 that, it is going to get at the brass, so there may be  
2 trouble.

3 STEINHAUER: You said a single potting procedure,  
4 or do you use a sequential operation, ultiple potting?

5 COLSTON: It is sequential. They put the plates  
6 in the cell cases with the wires sticking up, then the  
7 girl comes along and arranges them and bends them, fits  
8 the header on. They go through the whole lot. Then they  
9 come along and cut off the wires. Then they put the solder  
10 on. Then they come by with the bondmaster and apply it to  
11 each one. Then they go back through the lot and look for  
12 voids and visual inspection, this sort of thing, and touch-  
13 up.

14 STEINHAUER: There's not a second layer of  
15 bondmaster that goes over? It's a single pot?

16 COLSTON: I've only seen one layer.

17 RICHARDSON: Is this the only technique in  
18 making terminals for a silver cadmium cell? Could you use  
19 a comb technique like in the ni-cads? A mechanical seal  
20 joint or something?

21 COLSTON: Yes.

22 RICHARDSON: But this is the particular technique  
23 that Yardney uses, is that what you're saying?

24 COLSTON: This is the way they do it. There are  
25 other potting methods in the way you arrange the wires.



rms 37

1 And there is a comb. I have seen a comb on it.

2 RICHARDSON: These are non-vented cells; is that  
3 correct?

4 COLSTON: These are completely sealed cells in  
5 operation.

6 RICHARDSON: What type of material pressures are  
7 generated? Have you observed?

8 COLSTON: If it is a plastic case, you can't stand  
9 much pressure. Generally on the tests I've seen with the  
10 pressure gages and what-not we operate in a partial vacuum.

11 RICHARDSON: Most of the time?

12 COLSTON: Yes. We run it so that you get the  
13 gassing, say, in the last 10 percent of charge. These  
14 cells are nice in that the voltage rises toward the last  
15 part of charge. So, we can set a voltage limit, stop the  
16 cell before it is completely charged. We generally charge  
17 up to say about 150, 151 volts per cell. When it reaches  
18 that limit, the current tapers down to a level of about  
19 100 milliamps, then we go to open circuit voltage, in which  
20 in effect no current is taken from the cell or given to  
21 the cell.

22 RICHARDSON: For a general spec you might want  
23 to consider modifying that area on the terminals fabrication  
24 and sealing technique.

25 COLSTON: Yes, for a different manufacturer they

rms 38

1 would probably have a different terminal design.

2 READ: Read from General Electric.

3 I think this potting is a fairly critical area  
4 that perhaps might deserve more attention as to mentioning  
5 the materials that you actually use and the mixes that you  
6 use and this type of thing.

7 COLSTON: You mean within the cell around the  
8 lead-in wires?

9 READ: Yes, right here. This paragraph 3.4.2.5  
10 it seems pretty general. This was the area that I thought  
11 perhaps could be strengthened by material specifications  
12 and mixes.

13 COLSTON: It is a bondmaster mixture that they  
14 use, but it is not mentioned here.

15 Questions? Comments?

16 (No response.)

17 All right. Internal resistance measurement.  
18 We have a diagram for that on the back. This is to check  
19 for gross shorts.

20 Assembled cell dimensions and cell weight. And  
21 we also reweigh the cells when they come into Goddard.

22 SCOTT: Is there any point in leak testing? If  
23 so, I don't see any provisions or specs for leakage.

24 COLSTON: These cells, as delivered to Goddard,  
25 the header has a hole in it that's not sealed. And the header

rms 39

1 is not sealed to the case. And there's no electrolyte in  
2 the case.

3 HENNIGAN: There is a hundred percent leak check  
4 of the terminals.

5 SCOTT: All right. So, I guess the point is that  
6 this is strictly for use by the cell vendor when the cells  
7 are purchased in the dry condition.

8 COLSTON: Yes.

9 SCOTT: You have some internal leak limits then  
10 that you work to for your own final -- before you put the  
11 thing into the spacecraft?

12 COLSTON: Yes, he puts it in water.

13 HENNIGAN: We check them underwater, but don't  
14 forget that these cells are potted also.

15 COLSTON: After we assemble the battery, within  
16 the battery case there is a layer of potting.

17 HENNIGAN: There's no helium leak check. Let me  
18 put it that way.

19 GROSS: Gross, Boeing.

20 The cell specification then carries the process  
21 up to the point of putting the ingredients in the cell  
22 but not sealing it and adding electrolyte. Would it not  
23 also be useful to add to the specification the steps from  
24 then on that are done at Goddard, even though the specifi-  
25 cation is not required by the manufacturer, these are steps

rms 40

1 that you do that would be quite useful to be included in  
2 the spec.

3 COLSTON: Personally I don't want it included,  
4 but we have agreed on the need for coming out with a  
5 document, although we've given people handouts and what-not --  
6 coming out with a document describing what happens between  
7 the time these cells arrive at Goddard and we assemble the  
8 spacecraft battery from them. But personally I don't think  
9 they should be in the specs. That is a process that we do  
10 like to do ourselves.

11 RICHARDSON: Richardson, Marshall.

12 With the one hole -- do you know if the vendor  
13 runs a pressure check on the cell after he has put his  
14 cell cover on and sealed it? You know, you have the one  
15 hole available. Do you know if he just runs a pressure check  
16 on a cell to check out the seal. In other words, run maybe  
17 five or six pounds and watch for the pressure drop-off to  
18 check for leakage.

19 COLSTON: This would be on other people's  
20 batteries, or cells.

21 HENNIGAN: He will do that. That can be done.

22 RICHARDSON: Are they doing it on your cells?

23 HENNIGAN: They can't because these cells are not  
24 sealed. The cover is not sealed to the case.

25 RICHARDSON: Okay. Then do you do it here at

rms 41

1 Goddard after you seal the cover?

2 COLSTON: No, generally not.

3 HENNIGAN: We just check them underwater to see  
4 if we see any bubbles coming up. But these cells are potted  
5 and totally encapsulated.

6 RICHARDSON: Yes, I realize that. We have had  
7 some silver zincs that have leaked even though they were  
8 potted, so just because the top is potted -- in other words,  
9 you can get KOH and you run into a shorting problem, if  
10 the KOH leaks out on top of the cell. You can get shorts  
11 to the case. Shorts to terminals, and so on and so forth.

12 COLSTON: These cells are potted all the way  
13 around, and visual inspection is possible.

14 FLEISCHER: I will make one comment. I think  
15 testing of these cells should be very easy. For example,  
16 every Edison cell that was ever made -- and they were not  
17 sealed cells, they were vented cells -- was put underwater  
18 and tested at 50 pounds air pressure underwater to make  
19 sure that all the welds were sealed and that there was  
20 no leak in the cans.

21 So, it's very simple to do this, and it should  
22 be done.

23 GREEN: (Martin, Denver.) Just a quickie before ,  
24 the break.

25 I am listening here to this specification, and it

rms 42

1 appears to me under your statement that you did not want  
2 to include Marshall's processes, that if a contract  
3 should come out and the decision by the project office  
4 should be that the contractor shall buy and procure and  
5 furnish a battery with the unit that then he would not  
6 have a specification uniform as we're striving for unless  
7 he wrote it such that it would satisfy the requirements of  
8 Marshall for the consistency thereafter.

9 And if the purpose of this is to develop a  
10 uniform specification to assure quality products, we would  
11 have to have this other information so that we could buy a  
12 completed battery from a vendor. Is this not true?

13 COLSTON: Yes.

14 Let's take a break here.

15 (Recess.)

16 COLSTON: Okay, I'm told that we have to go a  
17 little bit faster. One comment I'd like to put in here.  
18 One reason why we get them dry -- when we get them dry,  
19 we can form them and fill them -- fill them and form them  
20 ourselves, take all the time, do triple inspection, do it  
21 very carefully and precisely. And also we've found that in  
22 getting them dry we can store them for up to five years and  
23 then fly with them, have a flight battery.

24 If we got them already formed and sealed and  
25 everything else, we'd probably have about a six to eight month

rms 43

1 limit about when we'd have to assemble a flight battery.

2 All right. We were on what -- cell assembly,  
3 3.4.2.

4 Then it gives a visual inspection procedure to  
5 make sure that they assemble the cell as per specifications.  
6 We have a maximum limit on the leads and tabs that the  
7 bin shall not exceed 75 degrees.

8 Terminal soldering. You have terminal potting.  
9 We've been through this. Polarity marking. Internal  
10 resistance. Cell weight.

11 Then responsibility for inspection. We use the  
12 supplier's QC people plus the D/CAS man, plus we have been  
13 to the plant during manufacture and talked with them and  
14 inspected them ourselves.

15 Then on the components, for the KOH we say  
16 basically that the stock solution be inspected in accordance  
17 to the manufacturer's procedures. We do like the components  
18 to be marked such that they can be identified for NASA  
19 Goddard or for space flight use. And so that they're  
20 traceable.

21 On the electrolyte then, we have mixing. We  
22 have sampling in which he does do the chemical analysis.  
23 Then we have a paragraph labelled marking. Here again we  
24 try to get it identified for NASA Goddard contract number  
25 for space flight use to try to keep these components separate

rms 44 1 from the general production silver cadmium cells. Then  
2 filling, bottle storage, packaging. And then we have  
3 silver powder. Now, here's your paragraph on electrical  
4 utilization. One plate from each of five cells in a  
5 production lot shall be tested at a charge rate of C/20  
6 in a 40 percent KOH electrolyte.

7 Then basically on acceptance tests it says  
8 do it the way they've been doing it but send us the  
9 results. And then more data on marking, on the silver  
10 powder containers.

11 And on the cadmium oxide powder, the same sort  
12 of marking, acceptance tests and sampling.

13 On the separator material we asked that the manu-  
14 facturer send us samples of the separator he proposes to use  
15 in the cell. And we also asked that he perform the wet-  
16 out test and send us the results.

17 Then we have an organic extractable test using  
18 a methanol solvent. For the silver treated cellophane --  
19 this would be for any cellophane -- send us samples.

20 SULKES: I have a question.

21 In regard to your bottles, you have the electro-  
22 lyte put into individual bottles for each cell; is that  
23 correct?

24 COLSTON: No, we usually get it in quart bottles,  
25 in polyethylene quart bottles.



rms 45

1 SULKES: I was looking under your bottle filling  
2 in 4.2.1.2, and it seemed to appear to be individual  
3 bottles. It doesn't matter then.

4 COLSTON: Further questions?

5 RICHARDSON: A comment. On that tab bending of  
6 75 degrees, can you clarify that a little bit?

7 COLSTON: We don't want the plates, the wires, or  
8 the tabs to be bent excessively. The idea is perhaps under  
9 vibration they could snap, this sort of thing. We like to  
10 see nice, uniform curves. We don't want to see edges where  
11 it has been bent too much and then straightened out.

12 RICHARDSON: I was just wondering if 75 degrees  
13 is a good criteria. You're talking about the assembled  
14 cell; is that right, the tabs after you put the plates  
15 back in the cell jar? Right?

16 COLSTON: Right.

17 RICHARDSON: How do you measure it? Do you just  
18 eyeball it?

19 COLSTON: Right. If you see something that looks  
20 bad, then you would pull the plate stack out. Remember  
21 these are not sealed. You could measure it.

22 Then for the wet thickness of the cellophane  
23 we call for 20 samples. And then the 24-hour soak and the  
24 thickness measuring device which I've described previously.  
25 Then we ask for the data from this measurement.

rms 46

1 Any more comments on marking? Storage. We like  
2 to see a humid atmosphere for the cellophane. If it gets  
3 too dry it tends to get brittle and hard to work with.  
4 It cracks and this sort of thing.

5 Then there are a few statements on care of the  
6 humidior-type boxes that they store it in.

7 Cell cases and covers. On the opposite page  
8 you'll see a picture of the case rupture test fixture.  
9 Here again the cases should be from the same lot.

10 Then next on the molding we ask for Bakelite  
11 C-11. Here in this place it doesn't say "or equivalent,"  
12 it should.

13 If machining is required, cases in covers will  
14 be annealed. It calls for rejecting on sandblasting. We  
15 like the headers sandblasted before they put the terminals  
16 on them because it is easier for us. We get the cells in,  
17 then when we are ready to use them we sandblast the rest of  
18 the case.

19 Demensions and internal pressures. Internal  
20 pressure test is a repeat of what we've given previously.  
21 It calls for 100 percent inspection, Storage. Grids.  
22 And then a catch-all statement on miscellaneous components.

23 Then on subunit assembly. The negative electrode.  
24 We call for a test every 50th weld. Basically what we're  
25 calling for is to hold the plate and pull the lead, and the

rms 47 1 lead should not come off without tearing the grid. There  
2 should be pieces of grid sticking to the lead when you  
3 pull it. This is destructive.

4 In the next paragraph on mixing it calls for  
5 EXMET. This could be "or equivalent." It describes how this  
6 particular type of cadmium oxide plate is made. The next  
7 paragraph calls for labelling of the cadmium oxide mix  
8 number. Then they call for a check on the proper electrode  
9 dimensions, waviness, flattness, cleanliness of the molds,  
10 and some more dimensions that are pertinent to this type  
11 of process. And it calls for where the five readings  
12 per plate shall be taken. Readings shall be made at three  
13 decimal places. And basically we ask them to send us the  
14 data.

15 Electrode weighing. We weigh to the nearest  
16 hundredth gram. And it shall include the leads. And they  
17 shall send us the result and include the data for the  
18 rejects.

19 Serialization. We like to have nice traceable  
20 numbers on every cell we get.

21 Storage. Sometimes in a dusty plant it is very  
22 useful since these cells are open to have plastic covering  
23 and what-not over the cell.

24 On the positive electrodes we call for readings,  
25 where they are to be taken, then send us the data.

rms 48

1 SULKES: I have a comment. In your negative  
2 electrode mixing and actually placing into the mold, do  
3 you intend this to be a center grid, or a grid really  
4 coming out on one side? This would seem to indicate that  
5 they dump it all in and put the grid on top, or the grid  
6 is in first. Whereas, I think you would like to have  
7 the grid right in the middle.

8 COLSTON: The end process produces a grid that's  
9 roughly in the middle.

10 SULKES: You don't require that half the mix be  
11 put in first and so on?

12 COLSTON: I've seen them -- let's see, on the  
13 process they put a little cadmium oxide down and then put  
14 the grid and finish it?

15 HENNIGAN: Right.

16 COLSTON: So they do do this. Any further questions  
17 or comments?

18 (No response.)

19 All right. On the positive electroe, the silver  
20 plates, again we call for weighings and data, the data to  
21 be sent to us.

22 Lead forging. Here again, five welded plates shall  
23 be tested for lead adhesion. You try to pull the lead off  
24 and the grid should come with it.

25 Serialization. Each electrode has a number.

rms 49

1 Storage. Then there is a section on the rolled silver  
2 strip.

3 Now, this would be modified depending on the  
4 procedure you use to produce the silver electrodes for  
5 other manufacturers.

6 All right. On the unit assembly, then cell  
7 assembly, they say care shall be taken not to lose the  
8 identify of the negative and the positive electrodes.  
9 And then they call for recording the numbers of the  
10 electrodes used in each cell.

11 Leads and tabs. Terminal soldering. Cover  
12 installation. Terminal potting. We've been through these  
13 previously.

14 Polarity marking. Internal resistance. And on  
15 the next page you see the diagram for the internal resistance  
16 set up.

17 Then we have a formula where the operator can plug  
18 in the data.

19 Assembled cell dimensions. The cell weight (dry).  
20 And Marking. Here again, we like the cells to be very  
21 nicely and legibly numbered with the date of manufacture,  
22 a serial number, this sort of thing.

23 Packaging. Well, we don't want metal bands  
24 attaching these groups together, because the bands can cut  
25 through. We do not -- this has been a problem because they

rms 50

1 like to do this evidently -- lubricate the terminals. We  
2 don't want them lubricated because we just have to turn  
3 around and try to get the lubricant off.

4 Then the next paragraph calls for Vermiculite.  
5 Now we have been shipped cells in boxes where they have  
6 all the loose Vermiculite, and that stuff makes a very  
7 nice dust. And on open cells it likes to get into the  
8 cell. I really don't know whether this affects the cell's  
9 performance, and I just don't want to have to be put in  
10 the position of having to find out.

11 Then we ask for accompanying these that they send  
12 us this data. And then marking, mil standard. In the  
13 past the letters for space flight use were not as obvious  
14 as they should be. They were put on with a magic marker.  
15 And then we have ordering data.

16 Now, personally we like to use these, the  
17 following dimensions and requirements. We like to know them  
18 and we like to know the cell design to this extent before  
19 we order. And we like to specify it.

20 Whether you do it when you order silver cadmium  
21 cells, if you order them, that's up to you. Then the supplier--  
22 this is where it says basically that this spec is written  
23 for Yardney. Perhaps it doesn't say it strongly enough.  
24 Then there are some definitions.

25 In the back here we have these test forms that we

rms 51

1 get our data on. WE get the dry and wet thickness, the  
2 rupture test data, the weight, size and thickness of  
3 the plates and the rejects. That concludes that particular  
4 specification.

5 Any questions, comments anecdotes, philosophy?

6 SULKES: Just one point, looking sort of ahead at  
7 your silver spec, you in the sil-cad spec allow a plus or  
8 minus 3.4 percent. In the silverplate spec for, let's say,  
9 zinc cells you're running it looks like about 2.8 percent.  
10 And it would appear if you could get it in that spec, it  
11 should be possible to achieve it here without any trouble.

12 So, this might be a little tightening up that you  
13 can do, or a loosening up the other one, depending on what's  
14 actually possible.

15 COLSTON: Yes.

16 PYDER: Ryder, Gulton Industries.

17 Did I understand you to say before that IMP was  
18 the program for which you developed this? Is this the  
19 only program on which you're using these cells.

20 COLSTON: These cells built in this manner have  
21 been used and flown on, let's see, seven IMPS dating  
22 back to 1962. We are presently building the batteries  
23 for IMP-I and later for IMP-H and J, also a silver cadmium  
24 battery for S cubed(?). We've looked at silver cadmium  
25 for PE, which is put off right now. And we have worked with

rms 52

1 the Belgians, the French and the Germans on silver cadmium  
2 batteries that they use.

3 RYDER: Thank you.

4 COLSTON: But basically at the present time  
5 there just doesn't seem to be that much business in silver  
6 cadmium cells.

7 BOGNER: I was wondering if it would be wise if  
8 you go out to other manufacturers if they would be interested  
9 in environmental requirements? Vibration, shock, thermal.

10 COLSTON: We perform, of course, vibration,  
11 shock and this sort of test here with the flight cells that  
12 we're going to use. We perform it on the battery.

13 RICHARDSON: What type of vibrational levels do  
14 you qual these things to? What maximum "G" levels? What  
15 frequency?

16 COLSTON: Do you remember?

17 HENNIGAN: I don't remember it offhand. It varies  
18 from shot to shot, but it is tied into the Thor-Delta.

19 RICHARDSON: Tied into what?

20 HENNIGAN: The Thor-Delta rocket.

21 RICHARDSON: You don't know if it's 10 G's? Five?  
22 Can you give me a ballpark?

23 HENNIGAN: I believe it is nine.

24 RICHARDSON: What frequency range?

25 HENNIGAN: A couple thousand, does that sound right?



rms 53

1 COLSTON: I would have to go back to the office  
2 and get the actual data.

3 RICHARDSON: Okay.

4 COLSTON: It is dependent on what your launch  
5 vehicle is, of course.

6 GREEN: Green, Martin.

7 Apparently you've had a lot of test experience  
8 with these batteries. Can you just roughly give me their  
9 performance comparison on high temperature and so forth,  
10 are they better than the nickel cad or are they a worse  
11 factor?

12 COLSTON: These batteries on the IMP program,  
13 I like to run them at roughly zero to 30°C. My most  
14 favorite range is 10 to 20°C. At above this temperature  
15 they tend to die quickly, and they operate nicely until they  
16 die though.

17 Below this temperature sometimes your charging  
18 regime, the voltage goes so high that you have trouble  
19 recharging it. And on discharge, say below 0°C sometimes  
20 you hit it with a, say a C/2 discharge rate or even almost  
21 a C rate discharge, your voltage drops initially so quickly  
22 that the undervoltage cutoff on a satellite system cuts off  
23 your battery. So, ideally I like to operate these things  
24 at zero to 30° C.

25 GREEN: How much shortening of life do you figure

rms 54

1 you might get at 30°C operation, just an estimate?

2 COLSTON: Mr. Hennigan says that 40° is less than  
3 a year and 50° is two months. And in the temperature  
4 range that I specified we tell the project managers we'll  
5 guarantee a year and it generally lasts two.

6 GREEN: Thank you.

7 FLEISCHER: I just want to be sure you carry  
8 out the environmental test, the shock test, on assembled  
9 batteries after they have all been formed, the cells have  
10 been formed and assembled. You don't do it on the cells  
11 themselves.

12 COLSTON: No. We might. If we had a problem we  
13 could take a couple of cells and walk over to the test  
14 area and have it done.

15 UCHIYAMA: Uchiyama, JPL.

16 I understand that these cells are flooded, vented?

17 COLSTON: No, not vented -- sealed.

18 UCHIYAMA: That's my question here. Just how do  
19 you go about assuring yourself/the seal, once you've  
20 activated the things, and do you have any requirements  
21 placed on the vendor relative to the subsequent seal that  
22 you people put on it?

23 COLSTON: None that is not in this spec. If they  
24 came up with something, some sort of defect that showed up  
25 later, and we thought that they did it, we could go back and

rms 55

1 have a heart-to-heart talk with them. But we usually  
2 don't have any trouble with the sealing on these batteries  
3 in orbit. See, we usually have at least one or two, perhaps  
4 three back-up batteries for each launch.

5 On launch we start testing the back-up batteries  
6 too. And we don't have problems with leaking.

7 RYDER: Ryder, Gulton.

8 You talk about like less than one year life and  
9 2 months or 2 years. Is this low orbit, and about what  
10 depth of discharge are you talking about. In other words,  
11 how many cycles are we talking about and what depth.

12 COLSTON: Okay. Typical IMP is a series that  
13 looks at the magnetosphere of the earth and the solar  
14 winds and the shock wave of the earth. The orbits range  
15 from a low point of say about 150 miles out to about  
16 280,000 miles. Some of them have a highly eccentric  
17 around the earth and go out beyond the moon.

18 IMP-E was anchored around the moon. The S  
19 cubed(?) will be an equatorial launch I think. Now,  
20 these things, usually the time of the orbit goes the mini-  
21 mum which so far has been eight hours. And it goes up to  
22 four days. We usually have up to about a 30 minute  
23 discharge, sometimes a 30 minute discharge continuously.  
24 We usually design these things for a 20-25 percent depth  
25 of discharge. We like to have about 6 hours to recharge them

rms 56

1 although we're working with the people on the German  
2 satellite, and they have a two-hour orbit. They are dis-  
3 charging for up to 25 minutes and recharging, a different  
4 recharge regime than our two-step voltage regulator. They  
5 are recharging in a hour and 35 minutes. The current rate  
6 of these cells is usually low. Say for a 10-ampere-hour  
7 cell the current rate is around 2 amps. On IMP-I it will  
8 be higher. It will be almost 7 amps. And we'd like to  
9 see about 10 to 20° Centigrade of environmental temperature.

10 UCHIYAMA: This question is kind of directed at  
11 Tom rather than to you. At one of the ECS meetings you  
12 mentioned the effect of radiation on the separator material.  
13 Do these specs now take that into consideration or were  
14 these specs generated before you had those problems with the  
15 separators?

16 HENNIGAN: The only tests we've done here on the  
17 radiation of sil-cad cells is cobalt source, and that  
18 was  $10^7$  rads. That was quite a heavy dose. Now the reason  
19 we did that is at one time we did have a battery failure  
20 and didn't quite understand it. And they were going into  
21 the belts more than they should have because of the orbit  
22 they got. And we checked it out, but of course the  
23 cellophane goes. There's not much you can do about it.

24 We finally found out that was not the source of  
25 the failure. It was we felt a problem of quality control.

rms 57

1 RICHARDSON: What's the most significant failure  
2 mode you found in the silver cad cells, assuming you operate  
3 them in the range of zero to 30°C normally operating temper-  
4 ature. What failure modes have you found.

5 COLSTON: They short out. The separator deterior-  
6 ates. The silver gets all in the separator.

7 RICHARDSON: After long cycling necessarily  
8 or short cycling.

9 COLSTON: After long life, heavy strain, with  
10 age. We've had a few failure modes of explosion where  
11 too much electrolyte was added. This was way back when.  
12 There have been a few other instances, but they just wear  
13 out.

14 This brings up one point. I'm sure that these  
15 specifications can be tightened so that we can get much  
16 better cases, headers, seals, potting, terminals -- the  
17 terminal can be redesigned and improved. But at the present  
18 time there's no point in it.

19 The basic system itself, the cadmium plate, a  
20 silver plate and cellophane in between lasts one to two  
21 years. And there's no point in having a 5-year terminal  
22 until someone improves the cellophane and probably the  
23 plates.

24 COHN: Cohn, NASA Headquarters.

25 The obvious answer to that is to look into the

rms 58

1 separators that were developed for sterilizable batteries  
2 where you potentially have much longer-lived separators,  
3 so that you might up-grade the whole system and expect  
4 longer life out of it.

5 COLSTON: We investigated this and -- what is it,  
6 the RAI separator --

7 HENNIGAN: We'll have to get some of the Borden  
8 separators and RAI -- there's a problem there with uniforming  
9 of separators. Can we get the same thing twice. The  
10 cells would not work. Very poor cycle life.

11 There is one thing that we have looked at and  
12 it looks promising. It is a calcium hydroxide coating which  
13 in a 50 cycle test restricted the silver migration one-  
14 tenth of what it was in a control cell without the coating,  
15 but it's been a little hard for us to get somebody to  
16 really control that coating for us. We have somebody now  
17 that will do it. And once we can get some cells made and  
18 cycle them, we'll have a bit more information.

19 STEMMLE: A comment here. It might be mis-  
20 leading to say you restricted at one-tenth. What you did  
21 was you reduced it to one-tenth of what it was previously.

22 HENNIGAN: Right.

23 STEINHAUER? Comment Steinhauer, Hughes.

24 Considering what you know now on the silver  
25 cad secondary system, how would you -- if you were starting

rms 59 :

1 today, would you go silver cad, or would you consider  
2 silver zinc?

3 .COLSTON: I'd still go silver cad on this use.

4 STEINHAUER: Why?

5 COLSTON: Well, these cells -- we don't get the  
6 watt hours per pound with silver zinc, but we are much  
7 better than nickel cad. The cells are very efficient in  
8 ampere hour current. We can charge up a battery and put it  
9 on the shelf for three months and then discharge it and  
10 get within 5 percent of what we put in it, so we're not  
11 sure if we actually put it in to begin with. So there's  
12 almost no self-discharge.

13 While it is sitting on the shelf the electrodes  
14 are not gassing like your silver zinc. These things operate  
15 in a partial vacuum, you know, inside the cell you don't  
16 have a gassing problem. It doesn't seem to have a real  
17 high rate that a silver zinc can do, but it's high enough  
18 and it has a longer life than a silver zinc.

19 And it's a nicer system, especially because of  
20 the gassing problem.

21 BOGNER: I think you have to qualify that when  
22 you say longer life. You may say cycle life, but total  
23 life, if cycles aren't important, will be nearly the same  
24 I think because you have the same failure mode usually,  
25 the silver penetration of the separator.

rms 60

1 COLSTON: Your zinc though likes to dissolve  
2 very readily too. Doesn't it?

3 BOGNER: Yes, you get some zinc, but a lot of  
4 cells I've seen haven't been due to zinc penetration.

5 STEMMLE: The zinc electrode actually is a bad  
6 actor. It sloughs off and you get active material in the  
7 bottom of the case.

8 BOGNER: You do get dendrite growth and sloughing  
9 off. But this does not affect the total life. Stand life.  
10 Shelf life. And it doesn't slough off when it is standing  
11 on the shelf, so what I'm saying is you've got to qualify  
12 it when you say life.

13 If you're talking about cycling it, over a short  
14 period of time you can get many more cycles usually out  
15 of the silver cad and the silver zinc. But if you only  
16 need 10 cycles over two years, maybe you can get it with a  
17 silver zinc.

18 PALANDATI: Palandati, Goddard.

19 In regards to the silver zinc systems that we  
20 have flown here at Goddard -- and these were Yardney silver  
21 zinc systems -- in regard to the cycle life, it was definitely  
22 nowhere near what you'd get on the silver cad cells and  
23 on your wet stand capability as such.

24 The wet stand I would say was questionable over  
25 18 months. And these were the Yardney silver zinc cells



rms 61

1 using the same U-fold(?) configuration with the same  
2 cellophane separator system and the number of wraps.  
3 It was definitely nowhere near as good as the silver cad cell  
4 even in wet staying(?) capability.

5 COLSTON: Are there any further questions on  
6 the silver cadmium system, if not, I think this is leading  
7 beautifully into the silver zinc?

8 HENNIGAN: One more comment on the sil-cad cell.  
9 We have finally with special loving care got these cells  
10 to stay together, if they're made together. And they do  
11 take these batteries down to full depth of discharge several  
12 times during the year. And we don't get any luxury like  
13 cell sensing, so we have to sense the battery. And we find  
14 if the cells are made according to spec, formed in a  
15 special way and selected, we can take these batteries down  
16 to 9/10th of a volt without reversal.

17 My experience with silver zinc -- I don't think --  
18 we haven't as much experience, but that's very difficult  
19 to do. They imbalance quite badly during cycling.

20 COLSTON: Yes, on a good lot on charge and  
21 discharge, these voltages stay together very nicely.

22 Well, shall we get to the silver zinc, Tom.

23 HENNIGAN: I'd like to go briefly through these  
24 two kind of first cut at specs on silver zinc and silver  
25 oxide plates. These specs were actually a cooperative effort

rms 62

1 between Goddard, Hughes Aircraft and ESB. We'll take  
2 the silver spec first. These were designed for approxi-  
3 mately a 12-ampere-hour cell.

4 We have the usual applicable documents in the  
5 front here, and our NASA Goddard drawing number. It's  
6 not on here, but it's just a dimensional -- I'm sorry,  
7 yes, the drawing is attached.

8 Okay, does anybody want any of these specs on  
9 the silver plate or zinc oxide?

10 These are requirements here in ampere hours  
11 nominal capacity of the silver plate. The design goal of  
12 this battery was for synchronous orbit, asking for as a  
13 goal three years. We have obtained as much as one and  
14 three-quarter years to day in the synchronous orbits with  
15 silver zinc batteries at room temperature.

16 The depth of discharge at the peaks on the ones  
17 we ran was 40 percent of the rated capacity. This we felt --  
18 we got a little bit higher to 60 percent. So, the charge  
19 time would actually be 23 hours, but using a two-step  
20 regulator you find at room temperature the battery charges  
21 up in about 13 hours. Then we cut it back so the charger  
22 is charging the battery -- if you want to use that term --  
23 at open circuit voltage.

24 The physical requirements are given and the plate  
25 weights. Now, again these were all 100 percent inspection

rms 63

1 to determine if the manufacturer could stay within these  
2 limits.

3 COHN: What's a DP?

4 CHREITZBERG: Dispersed plastic.

5 HENNIGAN: Dispersed plastic, right.

6 As you see here, we do have some values to  
7 reject outside of -- on the grids. It's pretty hard to  
8 specify that grid weight, the way I understand it. And  
9 the only way to do it is buy a \_\_\_\_\_ lot, and reject  
10 outside these limits.

11 The term "biscuit" used here is a term used as  
12 the silver electrode with the grid in it. Is that right,  
13 Gus?

14 CHREITZBERG: Yes.

15 HENNIGAN: That's a rather large sheet which we  
16 cut six plates out of?

17 CHREITZBERG: Yes.

18 HENNIGAN: Now, these biscuits were also  
19 lot grouped within the values that are shown here, the X  
20 plus or minus five percent.

21 Here, as I say, this is a first cut at this  
22 thing. Not all tests are specified. The ribbon is spot  
23 welded to the plate and inspected for integrity. We did  
24 have a spec on the plate density of the silver electrode.

25 Also there are some specifications here on the

rms 64

1 plate, electrical connection and the material to be used  
2 for it. Again, we're using EXMET materials as a grid.

3 The silver powder is specified as 99.9 percent.  
4 And with no other impurities exceeding 500 parts per  
5 million.

6 The grid is also specified in the sil cad one,  
7 we're also requesting here that the impurities be no  
8 greater than 500 parts per million.

9 STEINHAUER: Steinhauer, Hughes.

10 These levels of impurities were picked, as  
11 Dr. Fleischer suggested, from some of the major precious  
12 metals suppliers' specifications. It's not the entire  
13 spec, but those are the levels that you would normally  
14 expect there.

15 FLEISCHER: I think the government spec for this  
16 grade of silver has much lower impurity content.

17 STEINHAUER: For individual components I think --  
18 I'm not familiar with the government spec on it. I was  
19 looking at the manufacturer's specs, such as Engelhard and  
20 so forth.

21 HENNIGAN: The capacity of the plates is defined  
22 in ampere hours. And the current densities at which the  
23 plates should be operated are given here, how to charge it  
24 and so forth.

25 SULKES: Is there any reason why that capacity

rms 65

1 is so low? I notice you're allowing roughly 4.2 grams  
2 per ampere hour in this particular plate as opposed to  
3 two six in the sil-cad.

4 HENNIGAN: Well, I think Ed mentioned before,  
5 we felt that 2.6 number is wrong, way too low.

6 SULKES: You mean it's too efficient, too hard to  
7 meet it?

8 HENNIGAN: Too easy.

9 SULKES: Well on this one you are allowing four  
10 two, which is about twice as high. In other words, you  
11 need twice as much material to do the job in this one.

12 HENNIGAN: Was it grams per ampere hour?

13 SULKES: Grams per ampere hour, right.

14 And this one works out you've got an 8 gram  
15 \_\_\_\_\_ for silver material and you're only asking for  
16 2.1 ampere hours. That's foughly 4.2 grams per ampere hour  
17 as opposed to the sil cad where you're asking for 2.6 grams  
18 per ampere hour. You can't do much better than about two five  
19 roughly.

20 HENNIGAN: Did you have anything to say about  
21 that, Gus?

22 CHREITZBERG: If you take the positive plates and  
23 discharge them in excess electrolyte, they should do  
24 2.6. If you perform the test on the cell, specify the  
25 cell pack and run it at the C rate, then you would be at the

rms 66

1 limit that's now specified. You wouldn't be lower than  
2 that limit.

3 SULKES: This actually though is running against  
4 a dummy plate, so therefore I would think you would want a  
5 much higher performance level.

6 CHREITZBERG: The test that we normally perform is  
7 run not against dummy plates, but in a cell with a  
8 separator system similar to what will be used in the ultimate  
9 cell. And we would like to have the spec at the same  
10 rate as it will be flown. And then the limits will be  
11 meaningful. I think this limit is too low, in answer to  
12 your original question.

13 HENNIGAN: The current density of the plates to  
14 be used is given in the next paragraph. It mentions in  
15 paragraph 3.4 that the hundred percent sampling is done on  
16 plate thickness, height and width. Grid weight for the six-  
17 plate assembly, that's the grid that goes into this biscuit,  
18 and the sintered plate blank weight.

19 We also requested that the individual plate  
20 identifications be maintained as we do in the sil-cad area.

21 SULKES: This seems to be a special plate which  
22 is basically a low efficiency plate, and I'm sure there's a  
23 reason why you are using it. But it does appear to be  
24 special. I wonder if you could explain some of the rationale  
25 behind it.

rms 67

1 HENNIGAN: We asked the supplier to build the  
2 batteries for synchronous orbit. They contacted ESB, and  
3 this is their recommendation, is that right, Gus?

4 CHREITZBERG: I'm not sure what you mean by  
5 low efficiency. This plate should operate at the C rate at  
6 .28 ampere hours per gram minimum. And here I think we're  
7 specifying at .25.

8 Now, if you go above .28 ampere hours per gram,  
9 then you would have to specify the separator system  
10 and electrolyte concentration and so forth.

11 SULKES: The specifications as it calls out is  
12 four -- over four grams per ampere hour as the test is here.  
13 That's what I was questioning. In other words, you're  
14 asking for 2.1 ampere hours. On an 8.8 gram plate, if  
15 you're talking about 2-1/2 grams per ampere hour, you  
16 should be getting somewhere like 3-1/2 ampere hours out  
17 of that plate. So, I'm only questioning the capacity in  
18 this 331.

19 CHREITZBERG: I think that's a very good point.  
20 It should be increased. We have a lot of slop there.

21 That was

22 HENNIGAN: /before we requested all the positive  
23 plates be made from one lot of silver and one mix batch  
24 to be run and documentation be available to the purchaser.

25 For environmental requirements this was not imposed  
on the manufacturer necessarily. It was to give them some

rms 68

1 idea how we're going to use the cells. I kind of feel that  
2 the 100°F is too high if we want three-year life. If we  
3 flew this type of mission we would ask, as we do in the sil-  
4 cad area, zero to 25 or 30°C.

5 And then we specify the potassium hydroxide.  
6 We will use 40 percent. We call out the drawing and that  
7 they will measure to the drawing and that all the data  
8 will be supplied to Goddard.

9 The same way on the weights of grids, these  
10 so-called biscuits and plates is also to be supplied to  
11 Goddard, and the rejects are also to be -- we're supposed  
12 to know how many are rejected. Did you have a question?

13 COHN: No, but I have a comment. I notice on  
14 the drawing that you have one of those tremendous wires  
15 leading off that plate. Have you considered putting a  
16 tab on there instead of a wire to get better current  
17 distribution and maybe longer life and perhaps also have  
18 less trouble with kinking and splitting and so forth,  
19 getting a better bonding of the tab to the plate, instead  
20 of this small wire.

21 STEINHAUER: This is a tab.

22 COHN: It looks like a wire.

23 STEINHAUER: It is 10 mils thick and 60 mils  
24 wide. It's a ribbon.

25 COHN: What's the width of the plate?



rms 69

1

STEINHAUER: About the -- the whole plate?

2

COHN: Yes.

3

STEINHAUER: Two inches.

4

COHN: About two inches?

5

STEINHAUER: The plate itself?

6

COHN: Yes.

7

STEINHAUER: Two inches.

8

9

COHN: Have you considered using a tab about an inch or an inch and a half wide?

10

11

STEINHAUER: It's not really necessary in this application for the discharge currents that we expect it to carry. This is quite adequate.

12

13

14

COHN: You're going to use a very low rate of discharge and a very low rate of charge?

15

16

STEINHAUER: Yes, it is designed for about C rate discharge.

17

18

COHN: For the C rate?

19

20

21

COHN: Have you ever measured the plate with a full width tab and a plate with this kind of tab to see whether you can find differences in temperature distribution?

22

STEINHAUER: We have not.

23

24

COHN: I suggest you might do that sometime. If you operate them at the C rate, there's a good possibility that there will be an effect of the width of the tab and

25

rms 70

1 that you would gain in performance and in life by having  
2 a decent width of tab that is somewhere near the full  
3 width or however close you can get of the width of the  
4 plate rather than this bit of wire there.

5 RICHARDSON: With these types of wires or narrow  
6 tabs, we've experienced breakage during vibration testing  
7 with this type of arrangement. And you wind up with a  
8 reduced capacity in your cells when you break several wires.  
9 Now, with the wider tabs we haven't experienced this  
10 problem during vibration testing.

11 HENNIGAN: Well, this is similar to the ones  
12 we have in the sil-cad battery. It's a tab of this type.  
13 As far as I know, we've never broken a tab. We have had  
14 trouble with the integrity of the tab weld to the silver.  
15 As we've said before, the check is to pull it and make  
16 sure you've destroyed the plate before you pull the tab off.

17 STEINHAUER: In this batter design where these  
18 plates will be incorporated, the cell core or cell stack  
19 is not free to move. In other words, those tabs are not  
20 expected to be flexed during vibration.

21 RICHARDSON: When you get a cell pack like that,  
22 you can't make it too tight. Even in tight cells packs  
23 you can get movement of the plate stack within the cell  
24 jar.

25 STEINHAUER: Yes. On a normally constructed cell

rms 71

1 this makes use of separator frames. We have eliminated  
2 the U-fold. These frames are epoxied within the case, so  
3 that this whole stack is rigidized.

4 RICHARDSON: That's one way that I think you can  
5 possibly restrain the pack movement.

6 CHREITZBERG: The problem is certainly not as  
7 simple as going from wires to the screen. If you have a  
8 problem of cell pack design to a given vibration requirement  
9 such that the cell pack itself moves, it is a matter of  
10 time before the screen will break.

11 If you design properly, you can pass a vibration  
12 spec with either screen or wires. So, this is certainly  
13 a part of it, but not the entire picture. I think it is  
14 correct that you should have that amount of silver in the  
15 tab which will give you the proper conductivity and proper  
16 distribution.

17 From my experience the distribution of current  
18 is going to be a function of the screen inside the plate  
19 as well as the tab leading to the plate, especially at high  
20 states of charge.

21 And here the one zero grid might not be adequate  
22 to properly distribute it at high current rates.

23 FLEISCHER: I think this cell has one plate, one  
24 silver plate?

25 HENNIGAN: No, six.

rms 72

1 FLEISCHER: Six. Then the 2.2 ampere hours is  
2 the capacity of the plate itself -- one plate?

3 STEINHAUER: One plate.

4 FLEISCHER: Well, the C rate on that, the dis-  
5 charge in your lead wire amounts to about 3000 amps per  
6 square inch cross-sectional area, and I think this is  
7 nominal for silver leads.

8 HENNIGAN: What was that number again?

9 FLEISCHER: It calculates out to -- if you cal-  
10 culate the cross-sectional area of this lead, the 2.2  
11 amperes is roughly 3000 amperes per square inch, which is  
12 a nominal high rate discharge for silver.

13 HENNIGAN: This has to do with Ernst's remark  
14 about current density.

15 HENNIGAN: We will go on <sup>to</sup> the chemical section  
16 here, the silver powder. At this time we accept the receiving  
17 inspection of the manufacturer with a certificate of  
18 performance, the same as we do with the grid. Packaging was  
19 specified. This was rather a -- it wasn't so bad on the  
20 silverplate, but it's pretty hard to ship a dry silver  
21 oxide cell around. But this was specified so we would have  
22 some control on the packaging.

23 Identification is pretty standard here. There  
24 were some quality assurance provisions and inspection  
25 controls by the seller, GFC(?) through D-CAS and what to do

rms 73

1 with rejected assemblies.

2 I guess this sounds pretty boring, but this is  
3 about where we started with the sil-cad spec about five  
4 years ago, and if you keep working at it, eventually we  
5 might have a silver zinc spec similar to the sil-cad spec.  
6 I hope we don't have to tie it in so much to one supplier.

7 On the other one, the zinc oxide,  
8 the first page is -- or the first two paragraphs are  
9 essentially the same as the silver spec. In general here,  
10 we call out for a teflonated, unformed 5.5 ampere hour  
11 zinc oxide plate. It does say here the cell will have  
12 six positive and seven negatives.

13 Under paragraph 3.1, the physical requirements are  
14 given. And later on we specify that the 100 percent  
15 inspection should be done. And the composition of the zinc  
16 oxide mix is also given here.

17 SULKES: In view of some of the reports of the  
18 effectiveness of the extended edge plates, you don't  
19 allow the zinc to get smaller than the positive by toler-  
20 ancing, perhaps it should be toleranced such that the  
21 zinc should always be bigger.

22 In other words, rather than allowing 2.940 minus --  
23 in other words, only let it go on the plus side. And this  
24 way you'll always assure that your zinc is somewhat larger  
25 than your positive electrode.

rms 74

1 HENNIGAN: Well, we have some additional work  
2 being done where the zinc will be larger, about an eighth  
3 of an inch, would that sound about right?

4 SULKES: Well, an eighth is certainly fine, but  
5 even just by spec tolerances you can at least assure that  
6 you're getting, oh, 30 or 60 mils at a minimum.

7 HENNIGAN: Well, the grid is called out. Now, on  
8 this particular grid they did have a fold-back at the  
9 edges to strengthen the edge. Would that be to also have  
10 better adherence of the zinc oxide at that area?

11 STEINHAUER: It was felt that that would support  
12 the zinc oxide at the edge. Since that time where we've  
13 actually operated cells with this, we are somewhat con-  
14 cerned in that the EXMET with that fold-back thickness is  
15 about 35 mils when this is a 29-mil thick plate, so that  
16 you have EXMET right at the edge of the zinc oxide material  
17 around the periphery.

18 We may be running into some incipient short  
19 problems because of this fold-back. And we may have some  
20 afterthoughts on using this fold-back.

21 HENNIGAN: All right.

22 And the silver tab is spelled out here. Also  
23 on the other plates 100 percent inspection with lot plots  
24 of the entire plate lot with the low, normal and high values  
25 and their spread given on an X plus or minus some percent.

rms 75

1 The density of the zinc oxide is also spelled out. It is  
2 49 grams per cubic inch.

3 GREEN: Green, Martin.

4 I notice that you give the ~~plot~~ plates on the  
5 negative here, but you don't define any method of assembly  
6 like you do on the silver plates in the other specification.  
7 Any reason for that?

8 HENNIGAN: Any method of assembly?

9 GREEN: Yes, if you will look over in the other  
10 one, you make the statement that, "Make sandwiches using  
11 one grid and two nominal db sheets or one H and one L  
12 db sheet, allowing them assembly." But you do not do  
13 this in this other plate. Is there any reason for that.

14 HENNIGAN: Do you want to answer that, Gus?

15 CHREITZBERG: The processes are completely  
16 different. The description of the manufacture of the  
17 cadmium plate is very similar to the manufacture of the  
18 zinc plate here. We don't make two sheets and put them on  
19 either side of a grid in this case, so it is not described.

20 HENNIGAN: The plate electrical connection is  
21 spelled out here which is also shown on the drawing attached.  
22 The tab is called out to be attached to the silver grid  
23 in this case rather than in the silver case where we attach  
24 it to the silver center(?). And we ask for optimum weld  
25 process conditions. That turned out to be a pull test, if

rms 76

1 I remember right.

2 The EXMET grid is also called out as far as  
3 purity and weight per square inch.

4 On the chemical requirements the zinc oxide powder  
5 should be A.C.S. reagent grade. We didn't know at the time  
6 what the particle size should be so we asked the manufacturer  
7 to at least measure it, and we had the data. And we  
8 requested to have the data sent to us. The mercuric oxide  
9 use is also A.C.S. grade, and it is two percent of the  
10 total mix.

11 The teflon powder is not specified too closely  
12 here. It is Teflon 7, but we asked for some process con-  
13 trols that the manufacturer normally does to be performed.

14 The silver EXMET grid is also specified in the  
15 next paragraph.

16 The electrical requirements as far as capacity,  
17 the current density which we intend to use the cell at,  
18 and the depth of discharge of the cell is spelled out.  
19 It gives the manufacturer some idea how we intend to use these  
20 plates.

21 FLEISCHER: Tom, I want to go back to the teflon.  
22 As I recall, when the matter of the teflon carbon platinum  
23 black electrodes for fuel cells was discussed, it was  
24 very definitely brought out that one of the problems in  
25 making these things had been that teflon had a wetting



rms 77

1 agent in it. And this wetting agent apparently was changed  
2 from time to time without notifying anybody. In fact  
3 I don't think anybody really knew there was one in it, so  
4 here you are now going to introduce one of the things that's  
5 been bothering us. And you had no control indicated.

6 HENNIGAN: At this time I don't know if we can  
7 get enough information from duPont to control it. Could you  
8 guess?

9 CHREITZBERG: As far as I know there is no  
10 wetting agent.

11 SULKES: In some cases duPont 30, which I assume  
12 is similar, all these particles do have a wetting agent,  
13 however they are removed by a heat process. And I don't  
14 know if ESB is using it in this case. But if there would  
15 be one, there is no control on it as to temperature, time  
16 and so on.

17 Also control -- let's say uniformity of teflon  
18 dispersion, because in mixing these things you can get  
19 conglomerates and so on which you do want to avoid. So, I  
20 would say that the overall quality of the plate is left  
21 pretty much up to the manufacturer. You don't have too  
22 many controls on it, as perhaps you should be having.

23 HENNIGAN: As I mentioned before, this is a first  
24 cut at this thing. And it took us many years to get  
25 the other one out which is not perfect, and we feel it will

rms 78

1 take a few years to straighten this one out. You have  
2 to find out an awful lot of information over the years to  
3 write these types of specifications.

4 CHREITZBERG: One comment on the wetting agent.  
5 Teflon 30 is a mixture in a liquid, Teflon 7 is a dry  
6 powder. Teflon 30 requires a wetting agent for dispersion.  
7 Teflon 7, the dry powder, does not.

8 HENNIGAN: In the next paragraph on quality  
9 requirements, the usual 100 percent sampling is required  
10 to measure plate thickness, height and width. EXMET-type  
11 grid weight. Total plate weight and active mix weight by  
12 difference. Again this information is requested to be  
13 sent to the purchaser. Here they can't mix enough for this  
14 lot of cells, so we have to buy off on more mixed batches, but  
15 the powder is to be from the same lot. And again documen-  
16 tation is requested on this lot.

17 In the environmental requirements, again the  
18 temperature is specified as 30 to 100 degrees F. And if  
19 we would use these type of cells, we would like to keep  
20 that at zero to 25 or 30° C.

21 And the plates should be optimum in 40 percent  
22 KOH.

23 Under physical tests. This just requires that  
24 they meet the drawing and that the EXMET type grids and so  
25 forth and completed plates would be weighed, 100 percent

rms 79

1 inspection also required.

2 On this zinc oxide we would accept the conform-  
3 ance to the receiving lot inspection analysis and a certifi-  
4 cate of conformance to the lot. If you remember, these  
5 were A.C.S. grades.

6 Also for the mercuric oxide which is also A.C.S.  
7 On the chemical -- at least receiving lot analysis of the  
8 EXMET grid.

9 As far as preparation for delivery, I have  
10 some afterthoughts about shipping plates, dry silver oxide  
11 plates, that's a very difficult thing to do. And it  
12 probably would be better to -- Well, I don't know how we  
13 would do it the next time. This time they had to be  
14 hand-carried. WE'll have to figure that one out. They are  
15 quite fragile.

16 As far as identification, the usual information  
17 we want on the order and on the boxes that they come in.

18 And quality assurance provisions are essentially  
19 the same as before with government inspection and also  
20 data on the rejected assemblies.

21 And this last paragraph was put in by the plate  
22 manufacturer.

23 Well, as I say, these are pretty rough at this  
24 stage of the game. We would like to come up with a specifi-  
25 cation on silver zinc batteries as far as process type

rms 80

1 controls and material type controls that's a little more  
2 comparable to what we have on the sil-cad battery.

3 Does anybody have any general comments or  
4 questions?

5 SULKES: I would say these are a good first try,  
6 but really they are extremely specific to one particular  
7 battery. I think there's at least enough information to  
8 make a first stab at a general spec with individual  
9 technical specification sheets for each specific electrode.

10 In other words, a lot of these processes are  
11 general and could be in a -- let's call it a basic  
12 boilerplate, and you would just add on a few sheets to  
13 determine the specific electrode and not have to go over  
14 and redo a spec every time. Plus I think it would be  
15 helpful for other manufacturers. This one tends to be  
16 specific for only one. I think this would apply also to  
17 the sil-cad.

18 HENNIGAN: Do you want to help us on that, Martin?

19 (No response.)

20 Any more questions or general comments about the  
21 sil-cad or the silver zinc.

22 If not, it is 12:00. I think it is a good time  
23 to break. We are not going to adjourn this afternoon. We  
24 have to give up this room at 1:00. I certainly thank you  
25 all for coming. I know some of you came from quite a distance.

rms 81

1 And I hope you enjoyed this rather unusual meeting. I  
2 think it was a little different from the meetings you  
3 go to.

4 I think people were pretty open. There are  
5 certain steps in the processes that the companies have  
6 to respect. And If we know them, we have to respect the  
7 company.

8 So, thank you again very much for your attention.

9 (Whereupon, at 12:04 p.m., the meeting was  
10 concluded.)  
11  
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R.N.W. Blanket

# Transcript of Proceedings

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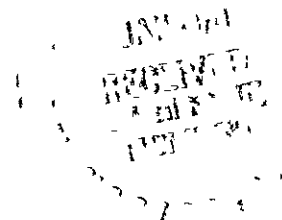
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on

SPACE BATTERY SPECIFICATIONS

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